

ASIATIC RESEARCHES;

OR,

Transactions of the Society,

INSTITUTED IN BENGAL,

FOR ENQUIRING INTO

THE HISTORY, THE ANTIQUITIES, THE ARTS AND
SCIENCES, AND LITERATURE

OF

A S I A.

VOLUME XVIII.

CALCUTTA:

PRINTED AT THE BENGAL MILITARY ORPHAN PRESS,
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1833.

ERRATA.

Page.	Line	
27	1	for "communications" read "communication."
28	3	insert "schist" after "argillaceous."
28	11	for "rocks" read "rock"
32	8	(of note) for "as" read "or."
33	8	for "on" read "in."
33	23	supply hyphen between "siliceo" and "argillaceous," and <i>dele comma.</i>
33	<i>last line</i>	for "hornblende slate" read "hornblend schist."
35	2	from bottom, for "Bayui" read "Bagur."
35	<i>last line</i>	for "Serul" read "Sciän" or "Scrol."
39	19	supply "a" before "quarter of an inch."
39	24	for "on" read "in."
41	2	from bottom, for "on" read "in"
42	2	from bottom, for "magnesia" read "magnesian"
44	7	<i>dele hyphen after "cylindrical" and supply comma.</i>
44	8	for "on" read "in."
44	14	for "on" read "in."
44	18	for "on" read "in."
44	2	from bottom, for "most" read "more."
45	9	for "stalk like" read "stalk-like."
45	18	for "position." read "portions."
50	2	from bottom, for "diagram below" read "diagram above." <i>In this page the diagram ought to have been placed in the position of the sketch and vice versa.</i>
	10	for "void" read "avoid."
		for "Bayui" read "Bagur."
55	1	for "Shivi" read "Serui."
63	8	for "furnace" read "forge."
67	24	for "calc schiste" read "calcschist."
69	5	for "schists" read "schist"
69	22	for "After" read "after," and substitute comma for period before "after."
71	7	for "on" read "in."
		from bottom, <i>dele "of" before "mechanical."</i>
		for "in the cross fracture" read "on the cross fracture."
		for "its sacred" "read "this sacred."
73	9	supply comma between "N. S."
81	18	<i>dele comma after "granites," and supply comma after "above."</i>
83	19	for "schistoses" read "schistose."
84	23	<i>dele hyphen between "quartz" and "hornblende," and supply comma.</i>
87	16	for "hills" read "beds."
108	6 & 13	for "Pecten" read "Pectens."
155	4	for "too likely" read "thus likely."
155	15	for "caves" read "caves."
156	6	for "island" read "islands."
157	2	(note at bottom) for "now" read "not."
158	22	for "some here" read "save here."
165	2	for "rising mangrove" read "mangrove rising."
168	11	for "County" read "Country."
172	<i>last line</i>	for "a large species" read "the."
176	<i>two last lines</i>	wrong stopped, for "with the margins, posteriorly dipped between them, &c." read "with the margins posteriorly;—dipped between them, &c."
130	6	from bottom, after the word "within," add "the stric being very faintly marked."
130	5	from bottom, <i>dele "muzzle dry" and substitute "between the nares a small moist muzzle: lips clad and dry."</i>
31	7	from top, <i>dele the word "straight" and add the words "flowing free, partially erected."</i>
136	8	from bottom, for "feet" read "fleet."

ASIATIC RESEARCHES.

TRANSACTIONS

PHYSICAL CLASS

ASIATIC SOCIETY OF BENGAL.

VOL. I.

CALCUTTA.

**PRINTED AT THE GOVERNMENT GAZETTE PRESS,
BY G. H. HUTTMANN.**

1829.

OFFICERS OF THE PHYSICAL CLASS
OF THE
ASIATIC SOCIETY.

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* * * The Members of the Asiatic Society, who have Superintended the Publication of the Transactions of the Physical Class, desire it may be known to the Public, that the Authors alone are responsible for the facts and opinions contained in their respective Papers.



INTRODUCTION.

IN offering to the Public the present portion of the Asiatic Researches in a distinct and separate form, and in thus deviating from the mode of publication which the Society has hitherto adopted, it appears expedient to state briefly the circumstances which have led to the present arrangement, and the motives by which it has been recommended.

Towards the close of 1827, several members of the Asiatic Society, who felt an interest in scientific enquiries, and who conceived that the ordinary Meetings of the Society were held at intervals too remote, and for purposes of too miscellaneous a nature to be calculated to promote scientific investigation, were induced to consider the most effective means to be pursued for the special furtherance of that object. On referring to the Minutes of the Society, it appeared that on the 7th of September, 1808, it was resolved, that “a Committee should be formed to propose such plans, and carry on such correspondence as might seem best suited to promote the knowledge of Natural History, Philosophy, Medicine, Improvements of the Arts and Sciences, and whatever is comprehended in the general term *Physics* ;” and a Committee was formed accordingly, and Meetings were held, but they had for sometime past been discontinued. The formation of the Committee was, therefore, recalled to the notice of the Society, and on the 2d of January, 1828, it was resolved at a General Meeting, that the Physical Committee should be considered as in

existence, and for the same purposes as formerly, exclusive of Medicine, for which a distinct Institution had already been established. Resolutions were, at the same time passed, empowering the Committee to elect its own officers, to frame its own rules, and to publish its proceedings as a distinct portion of the Asiatic Researches.

Upon the organization of the Committee, communications were invited from various parts of Hindustan, and the Papers consequently received, are now offered to the public. They are printed in the same form and type as the Asiatic Researches, of which they are an integral portion ; but they are so far distinct that they need not be necessarily incorporated with the Literary Transactions of the Society. By giving them a detached and separate existence, it has been thought that they would be more likely to attract the attention of the readers to whom they are chiefly addressed, or individuals engaged in scientific pursuits, than if they were associated with matters which are more especially addressed to literary men, or to the general reader.

The subjects to which the attention of the Physical Class of the Asiatic Society is principally directed, are the Zoology, Meteorology, Mineralogy, and Geology of Hindustan. To acquire an accurate knowledge of facts by observation and experiment, and to apply those facts to a sythetical explanation of particular phenomena, is the object of all Physical science. In those branches to which the attention of this class is particularly directed, facts may be accurately recorded even by the unscientific enquirer ; the connection of these facts and the deducing therefrom general conclusions, must be left to those whose habits of scientific combination and accuracy have qualified them for carrying on this last step in the process of induction. It was principally with the hope of collecting and recording with precision, facts, that this Class has been established. Scattered as are

our countrymen in the East, over so large a portion of the surface of the earth as yet unexplored by science, the most common observer can hardly fail to notice phenomena that may be important for the purpose of Physical Research; "*observationes fiunt spectando id quod natura per se ipsam sponte exhibet.*" BOSCOVICI. Few apparently as are the labourers in this vast field, it seems but little understood how competent those few are to make the most valuable additions to our knowledge. The Physical Class hopes to encourage the spirit of enquiry by the assurance that the labours of the observer will be no longer in vain. In order to assist persons unpractised in Geology, the Physical Class are about to republish DR. FITTON'S instructions for collecting Geological specimens with additional directions, which they are anxious to distribute as extensively as possible to all who have an opportunity of collecting specimens and forwarding them to the Society. It is with sincere gratification that the Members of this Class are enabled to state, that although a year and a few months have scarcely elapsed since its re-establishment, communications have been received, affording ample materials for a continuation of these Transactions, and that they have lost no time in placing a second part in the hands of their Printers.

It may be necessary to add a few words upon the mode adopted in the following pages of expressing native names in Roman characters, especially as they are mostly the names of places, which often assume a very different character in the text or maps of the present publication, from that which they wear in the most improved maps of ARROWSMITH or other Geographers. The system here adopted is that which is described by SIR WILLIAM JONES, in the first volume of the Asiatic Researches, and which has been followed with very few exceptions in all the subsequent volumes, as well as in the Transactions of the Royal Asiatic Society and of the Literary Society of Bombay. The orthography of the common maps

follows no rule whatever : the greater part of the names have been written down according to their fancied sound, and without any regard to their original characters, or to their signification. They are consequently in general so expressed that, to a native ear, they would be unintelligible, and they cease to convey what, in their correct form, they very commonly imply, some circumstances of interest respecting their history or origin, their topographical site, or peculiarities of soil, climate, and natural or manufactured produce. It would have been as idle as unphilosophical therefore to have adopted the forms of these names vulgarly expressed, especially in opposition to the practice followed by the highest authorities. Their enunciation will be sufficiently correct by attention to a few simple rules.*

* Thus — 1.—The Consonants should be pronounced as in English.

2.—The Vowels as in Italian, the long Vowels being distinguished by an accent over them.

There is one exception to the Italian sound of the Vowels, that of the short *a*, which takes the sound it has in *adorn*, *amend*, and similar verbs ; or as in *America*, or that of *u* in *Sun*, &c.

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GENERAL OBSERVATIONS
ON THE
GEOLOGY OF INDIA.

By JAMES CALDER, Esq.

It is singular to observe that, while England is ever ready to engage in enterprises to explore the secrets of nature, even in her most inaccessible retreats in other quarters of the globe, she should have shewn such supineness and indifference respecting the Natural History of her eastern dominions.

In the colonial possessions of other nations, the whole field of nature has been explored and described by scientific and enlightened travellers; whilst, in India, it has been almost entirely neglected, with one splendid exception, in which the munificent patronage of the East India Company has enabled a distinguished Member of our Society to make magnificent discoveries in the vegetable kingdom. May we not hope that the same patronage may be extended to other departments of Physical Science, and that, as Indian Botany has found its LINNÆUS, we may yet see the treasures of the Animal and Mineral kingdoms unfolded to us by a HUMBOLDT and a CUVIER.

In the field of Geology, indeed, some steady progress has been made, which the superintending care of the lamented VOYSEY promised to ripen into a rich harvest: fatally, however, for science, this ardent philosophic inquirer was a martyr in the cause to which he was devoted. His loss can only be duly appreciated by those who are aware of the great local knowledge and experience which he possessed, added to his general scientific acquirements, which so peculiarly qualified him for the task he had undertaken. The labors of DR. VOYSEY (which, had life been spared to him, a short period of time would have matured,) are not altogether lost. Some of his journals are in the possession of those who know how to estimate their value, and who, it is hoped, will be enabled to present the matter they contain to the public in as perfect a form as the incomplete state of the materials will permit. Availing ourselves partly of these materials, and of the scanty notices already in print, and the communications of the few valuable explorers now zealously engaged in scientific research, a few remarks may here be offered, by way of conveying some general view of the little we can yet pretend to know of the geological outlines of the vast field in the centre of which we are placed.

Casting our eye over the map of India, we are struck with the grand and extensive mountain ranges which form the principal boundaries. On the north we have the stupendous chain of the *Himalaya*, extending from the confines of *China* to *Cashmir*, and the basin of the *Oxus*; that vast accumulation of sublime peaks—the pinnacles of our globe—is so extensive, that a plane, resting on elevations of 21,000 feet, may be stretched in one direction as far as the *Hindu Coh*, for upwards of 1000 miles, above which rise loftier summits, increasing in height to nearly 6000 feet more. Primitive rocks alone have been found to compose all that has yet been explored of the elevated portion of that chain; *gneiss* being, according to Captain HERBERT, the predominating rock, along with *granite*,
mica-shist

mica-shist, hornblende-shist, chlorite-slate and crystalline lime-stone; on these repose *clay-slate*, and *flinty-slate*, and towards the base we find *sand-stone* composing the southern steps of the chain, and forming the N. E. barrier of the valley of the Jumna and Ganges, by which, and the diluvial plains of Upper Hindostan, this great Zone is separated from the mountain ranges of the peninsula. The opposite, or southern boundary of this valley, is of the same rock. Advancing to the south, we come to three inferior mountain ranges, on which the peninsular table land of India may be said to rest, or more properly, to which it owes its peculiar form and outline. We may consider these ranges separately, as the western or *Malabar*, the eastern or *Coromandel*, and the central or *Vindhya*.

The principal in elevation, and most remarkable in continuity of extent, is the western range, which commences in *Cundesh*, and runs along the Malabar coast, within a short distance of the sea, in an unbroken chain, to Cape Comorin, excepting where it is interrupted near its southern extremity, by the great chasm which opens into the valley of *Koimbetûr*. The direction of this range deviates but little from north and south, bending a little eastward towards its southern extremity; its elevation increases as it advances southward, the highest points being probably between latitudes 10° and 15° N. where peaks of granite rise to 6000 feet and upwards.* The northern extremity of this range is entirely covered by part of the extensive *overlying trap formation*, to be more particularly described hereafter; extending, in this quarter, from the sea-shore of the northern

* In Mr. Babington's paper, in the 5th volume of the Geological Society's Transactions, the height of one peak, *Bonassôn* hill, is stated to be 7000 feet above the sea, and in a recent description of the *Nilgiri* region, by Dr. Smith Young, the peak of *Dodapet*, situated between 11° and 12° S. Latitude, and 76° and 77° E. Longitude, is said to rise to an elevation of 8700 feet—it is to be regretted that we have no published report of heights, by actual geometrical or barometrical measurements, of the principal summits of the mountain ranges of the peninsula.

northern *Concan*, to a considerable distance eastward above and beyond the Ghats, as far perhaps as the river *Tumboodra* and *Nagpore*. These rocks assume all the various forms of *basaltic trap*, passing from the *prismatic* and *columnar* (of which some fine specimens are to be seen opposite to *Bassín*, near Bombay) into the *globular*, *tabular*, *porphyritic*, and *amygdaloidal*; the two latter containing an interesting variety of included minerals peculiar to such rocks. The landscape here exhibits all the characteristic features of basaltic countries. The hills rising abruptly in perpendicular masses of a tabular form, or in mural terraces, piled on each other, like great flights of steps leading to some giant's throne, are frequently separated by immense ravines—the whole clothed with luxuriant forests of teak and other trees, producing some of the most beautiful and romantic scenery of India. The elevation of this part of the range seldom exceeds 3000 feet; but advancing to the south, its height gradually increases, and granitic rocks begin to re-appear, rising above the surface between 17° and 18° N. Latitude, and from thence, probably, continuing to form the summits of the chain, with little interruption, all the way to Cape Comorin. In nearly the same parallel of latitude, this trap formation is observed to terminate also on the sea-coast, a little to the north of Fort Victoria, or *Bankot*, where it is succeeded by the *iron-clay* or *laterite*,* (a contemporaneous rock associating with *trap*) which
from

* We owe the first notice of this interesting Rock, which may, perhaps, be considered as peculiar to the Geology of this country, to Dr. Francis Buchanan, who gives the following description of it in his travels, vol. 3, p. 440. "What I have called indurated clay, is not the mineral so called by Mr. Kirwan, who has not described this of which I am now writing. It seems to be the *Argilla Lapidea* of Wallerius I. 395, and is one of the most valuable materials for building. It is diffused in immense masses, without any appearance of stratification, and is placed over the granite that forms the basis of Malayala. It is full of cavities and pores, and contains a very large quantity of iron, in the form of red and yellow ochres. In the mass, while excluded from the air, it is so soft, that any iron instrument readily cuts it, and is dug up in square masses with a pick-axe, and immediately cut into the shape wanted, with a trowel, or large knife. It very soon after becomes as hard as brick, and resists the air and water much better than any bricks that I have seen in India. I

from thence extends as the overlying rock, with little interruption, to the extremity of the peninsula, covering the base of the mountains, and the whole of the narrow belt of land that separates them from the sea, exhibiting a succession of low rounded hills and undulations, and reposing on the primitive rocks, which occasionally protrude above the surface, as at *Malwan*, *Calicut*, and some other points, where *granite*, for a short space, becomes the surface rock; from the main land, the *laterite* passes over into Ceylon, where it re-appears, under the name of *Kabúk*, and forms a similar deposit, of some extent, on the shore of that island. Passing onwards from the western, or *Malabar* coast, round the extremity of the peninsula, we leave this extensive *iron-clay* formation, and crossing the *granitic* plains of *Travancore*, which are strewed with enormous blocks of primitive rocks, we arrive at the termination of the chain. Here the eastern and western ranges appear united, and, converging to a point within about twenty miles of Cape Comorin, end abruptly at the *Amboli* pass in a bluff peak of *granite*, probably about 2000 feet high, from the base of which a low range of similar rocks, forming a natural barrier to the kingdom of Travancore, extends southward to the sea. It is to be remarked however, that the junction of the two great lateral ranges, (*viz.* the Malabar and Coromandel,) seems to take place at the Nilgherry hills, which rising into the loftiest summits of the peninsula, form the southern boundary

“ have never observed any animal or vegetable exuvia contained in it, but I have heard that such
 “ have been found immersed in its substance. As it is usually cut into the form of bricks for build-
 “ ing, in several of the native dialects, it is called the brick-stone (*Itica Culla*). Where, however,
 “ by the washing away of the soil, part of it has been exposed to the air, and has hardened into a
 “ rock, its colour becomes black, and its pores and inequalities give it a kind of resemblance to the
 “ skin of a person affected with cutaneous disorders; hence, in the Tamul language, it is called *Shuri*
 “ Cull, or itch-stone. The most proper English name would be *Laterite*, from *Lateritis*, the appel-
 “ lation that may be given to it in Science.” It is observed also on the shores of Sumatra and the
 Straits of Malacca, reposing on granitic rocks, particularly at Malacca, where that formation extends
 many miles inland, corresponding, in all respects, with that of the Malabar Coast.

boundary of the great table-land and the northern barrier of the remarkable valley of *Koimbutur*, from the opposite side of which proceeds the continuation of the mountain chains in one central range to the southern extremity, as already described. The whole of this western chain, and the narrow coast which lines its base, is remarkable for the absence of rivers and vallies of denudation, and, consequently, of alluvial plains or deposits of any extent. The precipitous sides of the mountains rising in some places, (to the south of Goa,) almost from the sea, are, nevertheless, covered in general by forests of the tallest trees and impenetrable jungles, which admit of gaining but a vague and scanty knowledge either of their geological features, or the mineral treasures with which they may abound.

The Island of Ceylon presents so much the appearance of having once formed part of the Continent of India, and there is such a striking similarity in the nature of its principal rocks (which are chiefly primitive,) to those of the mainland immediately opposite to it, that some notice of its geological structure should not here be omitted, of which Dr. Davy's valuable work affords the following interesting and scientific description.

“ In Ceylon, nothing is to be observed of that order of succession of rocks that occurs in Saxony and England, and many other parts of Europe. Uniformity of formation is the most remarkable feature in the geological structure of the Island; the whole of Ceylon, with few exceptions, consists of primitive rock unconnected with any other class of rocks, exclusive of those of very recent formation. Another remarkable geological circumstance is, that though the varieties of primitive rock are extremely numerous, almost infinite, yet the species are very few and seldom well defined.

“ The most prevailing species is *granite* or *gneiss*, the more limited are *quartz* rock, *hornblende* rock, and *dolomite* rock, and a few others which may be considered under the head of embedded minerals.

“ The varieties of *granite* and *gneiss* are innumerable, passing often from one into another, and assuming appearances for which, in small masses, it would be difficult to find out appropriate names, depending on composition and the proportions of the elements—or addition of new ingredients; regular *granite* is not common, *graphic granite* still rarer, it occurs at Trincomalee—neither is *sienite* common, it occurs in the Candyan provinces. Well formed *gneiss* is more abundant than *granite*, it frequently consists of white *felspar* and *quartz* in a finely crystalized state, with layers of black *mica*, containing numerous crystals of light coloured *garnets*. A similar rock is found on the opposite Continent, in the mountains at *Cotallum*, and affords one amongst other evidences of a conformity, if not identity, in geological character. Both the *granite* and *gneiss* of Ceylon, are much modified by an excess or deficiency of one or other of the ingredients. When *quartz* abounds in a fine granular state, the rock looks like *sand-stone*. When *felspar* or *adularia* abound, it acquires a new external character. This variety is common, and in some places it contains so much of these minerals that it may be called *adularia*, or *felspar* rock. When *mica* prevails in *gneiss*, (which is rare) it acquires not only the appearance, but very much the structure of *mica slate*.

The more limited varieties of *primitive rocks*, as *quartz*, *hornblende*, and *dolomite* rock, seldom occur in the form of mountain masses. The rocks of recent formation are *lime-stone* and *sand-stone*. The former is confined to the northern shore of the Island, where it appears to be still forming in the coral shallows of the adjoining sea. The other, (*sand-stone*) a rock of pretty general occurrence along the shore of the Island, which it may

may be said to surround by an interrupted chain chiefly between high and low water mark." The further detailed description of these rocks given by this scientific observer, and his account of the rich variety of beautiful minerals abounding in that Island, will be found highly interesting and instructive.

Proceeding on to the eastern side of the peninsular, and northward, along the foot of the mountains, we observe a country differing very considerably from the Malabar coast in appearance and geological character. The plains of the Coromandel coast form rather a broad though unequal belt of land between the mountains and the sea, exhibiting the alluvial deposits of all the rivers and streams that descend from the southern portion of the table land. The mountain chain that forms the eastern boundary of the peninsula, begins to diverge eastward where its continuity is interrupted by the valley of *Koimbatur* (already mentioned) From thence it breaks into a succession of parallel ranges, inferior in elevation and in unbroken continuity to the western chain; and in the further progress northward, after branching off into subordinate hilly ranges, occupying a wide tract of unexplored country, and affording vallies for the passage of the great rivers, that drain nearly all the waters of the peninsula into the Bay of Bengal, this eastern range may be said to terminate at the same latitude as that of the commencement of the western. *Granitic* rocks, (principally *sienite*,) seem to form the basis of the whole of these eastern ranges, appearing at most of the accessible summits, from Cape Comorin to Hyderabad. Resting on the *granite*, *gneiss*, and *mica-slate*, that form the sides and base of the mountains, are sometimes seen *clay-slate*, *hornblende-slate*, *flinty-slate*, *chlorite* and *talc-slate*, and primitive or crystalline *lime-stone*, affording, in some places, marbles of various colours, as in the district of *Tinnivelly*, near *Cotallum*, where *granite* is observed rising above the surface, in remarkable globular

or concentric lamellar concretions, and in apparently stratified masses, forming low detached hills, the strata of which dip at an angle of about 45° to the S. W.* Partial deposits, of the overlying rocks exist in this district, and of the black cotton soil, supposed to be produced by the decomposition of *trap rocks*. In the neighbourhood of Pondicherry, there are beds of compact *shelly lime-stone*, and some remarkable siliceous petrifactions, chiefly of the tamarind-tree, which have never been well described. The bed of the *Caveri*, or rather the alluvial deposits in the vicinity of *Trichinopoly*, produce a variety of gems corresponding to those of Ceylon : in general, however, the surface of the level country, as far north as the *Pennar* river, seems to consist of the debris of *granitic* rocks, and plains of *marine sand*, probably left by the retreat of the sea, with occasional alluvial deposits, and partial beds of *iron-clay*, and detached masses of other rocks of the overlying class. In approaching the *Pennar* river, the *iron-clay* formation expands over a larger surface, and *clay-slate* and *sand-stone* begin to appear. In the hills behind *Nellore*, are found specimens of a very rich copper ore, yielding from fifty to sixty per cent. of pure metal, according to Dr. HEYNE, besides argentiferous *galena*.

It

* These appearances, hitherto considered foreign to the nature or aspect of *granite rocks* in other parts of the globe, might be deemed questionable here, did they not coincide with similar appearances throughout the peninsula, and remarkably so with those of the Ceylon *granites* as thus described by Dr. DAVY. " In structure, the granitic varieties most commonly exhibit an appearance of stratification. It is not easy to decide with certainty whether this appearance is to be attributed to the mass being composed of strata, or of large laminæ or layers. I must confess I am more disposed to adopt the latter notion. I have found some great masses of rock decidedly of this structure ;—masses almost insulated, quite bare, several hundred feet high, in which the same layer might be observed spreading over the rock, like the coat of an onion ;—and which, if only partially exposed, might be considered a strong instance of stratification ;—and, if examined in different places, on the top and at each side, might be considered an extraordinary instance of the dip of the strata in opposite directions. With this hypothesis of the structure of the rocks, the appearance of stratification in all the granitic varieties may be easily reconciled."

It is to the observations of Drs. HEYNE and VOYSEY, that we owe all the information we yet possess of the vallies of the *Pennar*, the *Krishna*, and the *Godaverí* rivers. This interesting tract of country is not more remarkable as the ancient source of the most valuable productions of the mineral kingdom, being the repository of the Golconda diamonds;—than for the extraordinary geological features which it presents. The *Nella Malla* range of mountains, in which the *diamond-breccia* is found, is described by Dr. VOYSEY, as exhibiting a geological structure, that cannot easily be explained by either the Huttonian or Wernerian theories, the different rocks being so intermixed with regard to order of position, each in its turn being uppermost, that it is difficult to give a name to the formation that will apply in all places: the *clay-slate* formation is the name he has adopted, under which are included *clay-slate*, every variety of *slaty lime-stone*, *sand-stone*, *breccia*, *flinty-slate*, *horn-stone-slate* and a *tufaceous lime-stone*, containing, embedded in it fragments, (rounded and angular) of all these rocks—all passing into each other by such insensible gradations, as well as by abrupt transitions, as to defy arrangement, and render description useless. It is bounded by *granite*, which passes under it, and forms its base, some elevated points, such as *Naggery Nose*, having only their upper third composed of *sand-stone* and *quartz*, while the basis is generally *granite* or *sienite*.

The rocks above enumerated, with beds of compact *lime-stone*, resembling *lias*, of various colours, and the addition of the *iron-clay* and *basaltic* rocks, occupy extensive portions of the valleys of the *Krishna* and *Godaverí*, covered in some places by the black *trap* soil; a *sienitic granite* however, composed of *hornblende*, and sometimes *mica*, with *quartz*, *felspar*, and *garnets*, interspersed, forms the basis of the ranges that separate these rivers. From *Condapilli* northward, the *granite* is often penetrated, and apparently heaved up by injected veins or masses of *trap* and dykes of *green-stone*.

green-stone. We hope soon to be enabled to lay before the Society, a detailed description of these formations, accompanied by sections of the strata between Madras and Hyderabad. The waters of the *Krishna* and *Godaveri* expand as they approach the sea, dividing into numerous branches, and depositing their alluvial contents during inundations over the low level tract that separates them: these deposits consist, according to Dr. HEYNE, of a black earth, resting on *indurated marl*, and composed partly of the debris of *trap* rocks, but chiefly of decayed vegetable matter, yielded by the extensive forests through which these rivers flow. Here may be noticed a characteristic difference that marks the alluvial deposits of the principal river of the south—the *Caveri*. This river, flowing in a long course through the Mysore country, over an extensive and generally barren surface of *granitic* rocks, with scarcely any woods or jungle on its banks, seems to bring down little or no vegetable alluvium; but a rich clay, produced by the *felspar*, which predominates in the *granites* of the south, intermixed with decomposed *calcareous conglomerate*, rendering the plains of Tanjore the most fertile portion of the south of India.

Passing on to *Vizagapatam* and *Ganjam*, *granitic* rocks, chiefly *syenite* and *gneiss*, predominate, and are occasionally covered by *laterite*. The *granite* of *Vizagapatam* assumes a new and singular appearance, being small-grained, and intermixed with amorphous garnets, in rounded grains, or specks. This peculiar rock passes into the Province of Cuttack. The only information we possess regarding that interesting district, is derived from Mr. STIRLING's valuable paper in the last volume of the Asiatic Researches. Rocks of the *granitic* class form the basis and principal elevations of this district; some of them are remarkable for their resemblance to *sand-stone*, and abounding in imperfectly formed *garnets*, disseminated throughout, with veins of *steatite*. Here some traces of coal have recently been discovered, which is likely to be productive, and gold is found in the sands of the *Mahanadi*, brought down
probably

probably from the valley of *Sambhalpur*. We next trace the *laterite*, as the overlying rock, through the district of *Medinipur*, and thence continuing northward by *Bishenpur* and *Bancora* to *Bírbhúm*, reposing sometimes on *sand-stone*, but more frequently on *granite* or *gneiss*. At *Bancora*, the calcareous concretion called *Kankar*, begins to cover the surface of the *granitic* and *sienite rocks*, which rise above the surface to considerable elevations in that district.

Thence we pass on to the great coal field that occupies both sides of the river *Damoda*. The boundaries of this formation have not yet been accurately ascertained: to the southward we trace its associating rocks (*sand-stone* and *shales*) to within a few miles of *Raghunáthpur*, reposing on *granite* and *sienite*—about forty miles north by east; from that place we come to the first colliery ever opened in India. The late Mr. JONES, an enterprising miner, had the merit of commencing these works in 1815, at a place called *Rání Ganj*, on the left bank of the *Damoda*. Mr. JONES describes this as the N. W. coal district of Bengal: he states that he observed the line of bearing for sixty-five miles in one direction, its breadth towards *Bancora*, (on the S. W. side) being not more than eleven or twelve miles from the river; and he conjectures that the same coal formation crossing the valley of the *Ganges*, near *Catwa*, unites with that of *Sylhet* and *Cachar*, which he denominates the N. E. coal district, and from which abundant specimens of coal have been produced. An accurate survey of this extensive and valuable deposit seems to be called for, by obvious considerations of the most important public advantage.

The principal rocks that compose this formation are varieties of *sand-stone*, *slate-clay*, and *shales*, with occasional dykes and veins of *trap* and *green-stone*; the *shale* immediately covering the coal, abounds with vegetable impressions, and some animal organic remains; amongst these,

Dr.

Dr. VOYSEY distinguished a *phytolithus*, a *calamite*, a *lycopodium*, and one specimen of a gigantic species of *patella*. The *shale* passes into *slate-clay*, above which succeeds a *gritty, micaceous, brownish-grey, sand-stone*, here and there becoming *indurated* and *slaty*—this forms the surface rock all over the coal district, rising into low round - topt hills and undulated grounds. In the coal pits (three in number,) which have, only yet been sunk to a depth of about ninety feet, seven seams of coal have been met with, one of which exceeds nine feet in thickness: the quality of the coal (which is now consumed largely in and about Calcutta,) somewhat resembles the Sunderland coal, but leaves a larger proportion of cinders and ashes.

Proceeding northward and westward, from *Bancora*, and the *Damoda* river, the road to *Benares* passes over *granitic rocks*, of which the ranges of hills on the left, and the whole country, as far as the *Sone* and round by *Shirgháti* and *Gaya*, is probably composed. On approaching the *Sone* river, and crossing the hills behind *Sasseram*, *sand-stone* begins to appear, and continues to be the surface rock, with probably only one considerable interval, all the way to *Agra*, forming, as before noticed, the southern barrier of the valley of the *Ganges* and *Jumna*; that interval occurs in the low lands of *Bundelkhand*, where the remarkable isolated hills, forming ridges, running S. W. and N. E. are all *granitic*, the high lands being covered with *sand-stone*. This brings us back to the rocky plains of Upper Hindustan, and to the last of the three principal mountain ranges first alluded to. The *Vindhya Zone*, crossing the Continent, from east to west, may be said to unite the northern extremities of the two great ranges already described, which terminate nearly in the same parallel of latitude, forming, as it were, the base of the triangle that elevates the table land of the peninsula. This great chain, yielding little in classical character to the *Himálaya*, intersects the heart of the country, and is distinctly

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traceable,

traceable, even in our very imperfect maps, running about S. 75° W. from the point called the *Rangerh* hills, towards *Guzerat*: this range has numerous divisions and a multitude of names, almost every district giving a change of denomination, but to the eye of a Geologist who considers things on an extended scale, there is a parallelism in the disjointed parts, and a general connection and dependance on the central range; the substrata prove this fact, for in every case they preserve that parallelism. The great surface formations of central India and the *Delhin*, are the *granitic*, (including always *gneiss and sienite*) the *sand-stone*, and the *overlying rocks*; the latter exceeding in their extent those of any other country. The *basaltic trap* formation extends northward all over *Malwa* and *Ságar*, and eastward towards *Sohagpur* and *Amerakantak*;* thence proceeding southward by *Nagpur*, it sweeps the western confines of *Hyderabad*, nearly to the fifteenth parallel of latitude, and bending to the N. W. connects with the sea near *Fort Victoria*, as already noticed, composing the shores of the *Concan* northward, all the way to the mouth of the *Nerbadda*, covering an area of upwards of 200,000 square miles. It overlies *sand-stone* in the district of *Ságar*, and hence may be inferred, that a portion of it at least is posterior to *sand-stone*: it possesses the common property of *trap* rocks in general, viz. that of changing the nature of every other rock which comes in contact with it; and in the district of *Ságar*, it is always associated with an earthy *lime-stone*, which seems to have undergone great change, strongly indicating the agency of heat. According to Captain FRANKLIN, the *sand-stone* deposits are very regular both in their deposition and geological character, and cannot well be mistaken; their general parallelism to the horizon, and their saliferous nature, appear to him to identify them with the *new red sand-stone* of England, whilst the *red marle*,
and

* It is expected, that the limits of this eastern deposit of *trap* will soon be more accurately determined by Captain FRANKLIN.

and its superincumbent variegated or mottled variety, (called by Werner *bunter-sand-stein*,) together with the deposits of *lias lime-stone*, place the matter almost beyond a doubt. In using the term *new red sand-stone*, however, it must be understood, as it is in England, to comprise all that series of beds which intervenes between the *lias lime-stone* and the *coal measures*; admitting which, he conceives that the water-falls of *Bundelkhand*, which occur in the lowest steps of the *Vindhya range*, will afford a series of formations corresponding perfectly with those of England; and to that school, therefore, our attention should be directed, in order to arrive at satisfactory conclusions regarding it.

On the western side of India it is, as we have seen, covered by overlying rocks, as at *Ságar*: it appears, however, flanking the large primitive branch which runs to *Udaypur*, on the side of *Guzerat*; and to the north it sweeps into the desert to an unknown extent. A paper of Mr. Fraser's, in the London Geological Transactions, proves this fact, even if we had not the more substantial evidence of rock-salt, which is there produced in abundance.

The next of the great surface rocks of central India, is large-grained *granite*, frequently passing into *gneiss*, generally composed of *quartz*, *flesh-coloured felspar*, a little brown or black *mica* and *hornblende*; it varies, however, in appearance, and also in the proportion of its constituents; but, generally speaking, it contains large crystals of *felspar*, and is, consequently, much subject to decomposition; Captain FRANKLIN has specimens shewing its unequivocal passage into *green-stone*, and, in some instances, it resembles *green-stone porphyry*, as in a small water course at the foot of the *Bairanganj Ghat*, in *Bundelkhand*: it sometimes also, he observes, resembles *euphotide*, and, in many cases, it would be difficult to decide whether it be *granite* or *sienite*; this circumstance renders it desirable that it

it should receive further examination; it extends all over the southern part of the peninsula, after the *trap* and *sand-stone* disappear, and it lies so near the surface that it is constantly protruding through the superior strata all over India, all the valleys of denudation bring it to light, and the plains of *Bundelkhand* are entirely composed of it; the veins of *quartz rock*, with which it is constantly associated, forming, in general, the spine of the hills.

The vallies of denudation are almost the only places where the *primitive stratified rocks* can be observed with advantage, and even there it is rare to obtain a good section of them; it is not because they do not exist in India, as in other countries, it is because they are, for the most part, buried beneath a mass of superincumbent *trap*; still however, there are occasional spots where they are found *in situ*, as in the *Udaypur* branch of the primitive chain, the small primitive ramification on the verge of the *trap* near *Jabalpur*, and many other places not necessary to mention; but the vallies of denudation sometimes exhibit a series, as in the bed of the *Nerbudda* river, at *Beragerh*, near *Garrah*, and it is there chiefly that these rocks can be studied advantageously.

With regard to the rocks of more recent formation than *sand-stone*, India is peculiarly barren; but this circumstance, above all others, renders its geology interesting—if it be in reality so, whence does such a remarkable distinction proceed? the reply may comprehend a solution of the most important phenomena of the science.

The *lias* formation is as yet known only from Captain FRANKLIN'S researches; he has found it in *Bundelkhand* *in situ*, reposing on *red marle*, or *new red sand-stone*; its general geological character appears to correspond with the same formation in England, and its light-coloured or
most

most compact varieties have been found to answer some useful purposes of lithography, although none has yet been discovered equal to the true lithographic stone of Europe. Neither *oolites* nor *chalk*, have yet been discovered by Captain FRANKLIN, although he has traversed not only the range of hills, at the foot of which the *lias* is found, but the whole adjoining country, and the absence of these rocks in the tract that has fallen under his examination, forms, in his opinion, a remarkable peculiarity.

This, therefore, is one of our great objects of research, viz. to ascertain whether in all other parts of India, the *oolitic* and later regular formations are thus wanting, nor should the concretionary rocks be excluded from this enquiry; of these the most remarkable is that singular calcareous deposit called, in the Bengal provinces, *kankar*, and known by other names in the south of India. It appears in a variety of forms and in different relative positions in different places." Sometimes in *nodules*, *globular concretions*, or *rolled masses*, scattered over the surface of valleys and rocky plains; at other times in horizontal beds and layers, at various depths in the alluvial deposits of the rivers and plains of Hindustan. Its prevalence is very extensive, although less abundant in the southern quarter of the peninsula; neither has it yet been observed on the Malabar Coast,* and in Bengal it appears to be bounded to the eastward by the *Gandak* river. From its peculiar appearance in some places it has been considered as *calc tuff*, and by some mineralogists would, perhaps, be classed* under that denomination. Common *kankar*, on analysis, is found to contain the elements of *oolite* and *chalk*. May not this concretionary formation therefore, which seems peculiar to India, be the ruins of what, under different circumstances, might have become regular *oolitic* strata? Captain FRANKLIN observes,

* It should be remarked, that the prevailing *Laterite* of that coast is characterised by a proportion of *Calcareous* matter in its composition.

observes, that these irregular beds of *kankar*, which are found following every water course, and forming its banks, have often the appearance of having been deposited under circumstances peculiarly unfavourable to regularity; and it may be asked, to what agency but that of running and turbulent water can such appearances be satisfactorily ascribed?

The absence of those regular formations which are known to exist in other countries is, however, a geological question of the first importance that must not be hastily taken up or hypothetically assumed, and nothing but reiterated and satisfactory proof of their non-existence ought to be considered admissible. A careful discrimination is also necessary, so as not to confound with *chalk*, the numerous *steatitic* deposits which are known to exist, and are used in India as substitutes for it; the *oolites* indeed cannot well be mistaken, because their peculiarity of structure readily points them out; but the most important of all distinctions are, *geological position* and *association*, without attention to which all observations will necessarily lose much of their value as useful facts.

With regard to organic remains, (the most interesting of all the branches of geological science,) it is to be feared that India is not likely to prove a productive field. The coal strata, when public spirit and enterprise shall excavate them, will, probably, afford other varieties of impressions of vegetables and fishes, besides those already mentioned, and the *lias lime-stone* may contain specimens of the *sauri* tribe; but hitherto, the most striking phenomenon in Indian geology is the almost total absence of organic remains in the stratified rocks and in the diluvial soil. *Sharks'-teeth* and *palates*, are found in the diluvian banks of the *Ganges*. In the *lime-stones* and alluvial deposits of *Sylhet* and *Cachar*, the interesting researches of Mr. SCOTT, have discovered *nummulites* and other shells, which appeared to Dr. VOYSEY to be *diluvian*, or even of modern existence,

live

live shells of exact resemblance to them being found, in the vicinity, with the exception of *ammulites*. Silicified-wood has been found in the diluvium of *Calcutta* and *Jebbelpur*; but bones of animals have never yet, we believe, been discovered either in diluvium or in stratified rocks. In this branch however, the extensive deposits of fossil bones recently discovered in *Ava*, apparently antediluvian, and perhaps the yet unexplored caverns in the lime-stone strata of *Sylhet*, *Cachar*, and *Assam*, promise a field for future successful research. Of the alluvial delta of Bengal, the bed of the *Ganges*, and the country to the eastward of it, we are at present unable to add anything of importance to the information given by Dr. ADAM, Mr. SCOTT, and Mr. BENSON, in their interesting communications already published, nor do we possess as yet sufficiently connected materials for giving even a superficial view of the geological outlines of the countries to the north-west, but we may look to some zealous explorers now actively employed, for an early extension of our geological knowledge in that direction.* The Bombay Literary Society will, no doubt, be able to collect much interesting information from that quarter, especially as it is understood that the coal field long since discovered in *Cutch*, by the late Captain McMURDO, is now likely to be worked. I have said nothing about the lead mines of *Ajmer*, nor of the ores of that and other metals that have been discovered and worked in former times, in various parts of India, particularly the extensive and important class of iron ores, which abound almost every where, and in greater variety than, perhaps, is to be found in any other country.†

From

* Specimens said to be from the Province of *Cutch*, have been seen by Dr. HARDIE, which lead him to expect that we shall, in all probability, discover, in that quarter, some of the newer class of rocks posterior to the *lias*, which are in so remarkable a degree wanting in other quarters of India.

† Captain FRANKLIN has been engaged in examining the iron ores of the valley of the *Narmada*, and Captains COULTHARD and DICKSON, in the districts of *Segar* and *Ajmer*, have furnished interesting communications, which will appear in our Researches.

From the above desultory observations, it would appear, that the Geology of India is far less complex, than that of most other countries, of the Geology of which any thing is known. It is said* that, instead of twenty different formations, as in England, there are in India only four, viz. The *granitic*, the *sand-stone* and *clay-slate*, the *trap*, and the *diluvial*; with their respective subordinate rocks, each of which formations possesses characteristics in common, that strongly mark their cotemporariety. This conclusion, however, requires some modification. We have the *primary* series, both stratified and unstratified, in complete succession. We have the *transition* class—the *carboniferous* order, and also the *secondary* class—nor does there appear to be any thing anomalous, until we ascend in the series to the *overlying* rocks of the *trap* family; these rocks, as has been shewn in another part of this paper, form the most striking feature of our Geology, and as some of them at least are proved to be of a later epoch than *secondary sand-stone*, it is apparently to the period of their formation (whatever may be their origin,) that we must refer the commencement of anomalous appearances.

In this view of the Geology of India, therefore, our safest plan will be to confine ourselves as much as possible, within simple rules, and to such terms of nomenclature as may least embarrass the subject. The best writers in the Transactions of the Geological Society of London, seem to have very generally adopted the synoptical arrangement, which is given in the introduction to Conybeare, and Phillips's Outlines of the Geology of England and Wales; and it is to be presumed that they have done so after due consideration. The English Geologists have certainly shewn,
that

* By the late Dr. Voysey in a letter to Dr. Abel.

that they are less inclined to theorise than those of other countries: indeed, the series of their rocks is so complete, that they have not needed it: their labours have consisted in the accumulation of facts, and the scene of their operations being so confined, compared with the extensive field in other countries, they have been able to visit almost every formation with minute investigation. This we have no present hope of being able to accomplish in India; but we may, nevertheless, follow their example in the simplicity of our arrangement, and in the precision of our nomenclature; and it would seem that our adoption of the synoptical arrangement above mentioned, as far as practicable, by leading to an uniformity in our pursuits, and, what is still more important, to an identification of our principal Geological Strata with those of Europe, will preserve us from many errors: it will, besides, prove advantageous in rendering our descriptions more intelligible to all persons in England, who may be interested in the Geology of India.

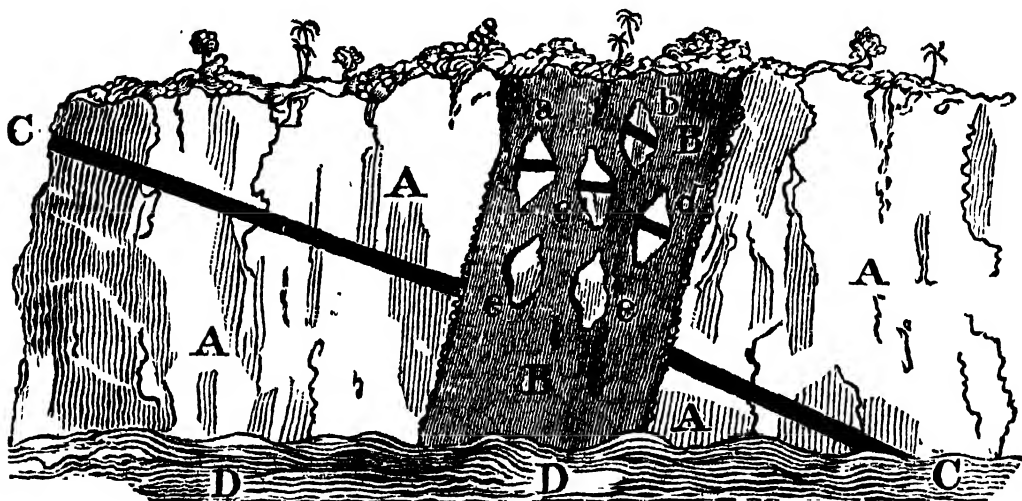
NOTE.

The occurrence of *basaltic veins*, traversing the *granitic rocks* of Central and Southern India, is not unfrequent, and has been particularly noticed by Dr. VOYSEY.

In travelling from Madras to Mangalore, many years ago, I observed one of those veins possessing peculiarities that may render its description somewhat interesting to the Geologist. It occurs in the rocky bed of a small detached branch of the river *Caveri*—at a spot distant about two miles west from the fort and island of *Seringapatam*; here the prevailing rock is SIENITIC GRANITE, which, on the left bank, rises in nearly a perpendicular face to about fifteen or twenty feet above the stream. In this rock, there is a vertical *dyke*, or *vein* of compact *basaltic trap*, ten or twelve feet broad, and of uniform thickness (its sides being parallel) from top to bottom—a small vein of *black scaly hornblende*, about two inches in thickness, traverses the *sienitic rock*, obliquely, and it is distinctly perceptible that this vein has been disrupted by the *whyn dyke*, for, in the midst of the *basaltic vein*, there

are fragments of the *sienitic rock*; some of them from one to two feet in diameter, which contain portions of the *hornblende vein*, so perfect and entire as to indicate the precise spot from which they must have come; and it is particularly remarkable, that all these fragments appear to have been carried upwards, considerably above the level of the *hornblende vein* which, with its containing rock, is obviously of anterior origin to the *trap* vein—a fact that is also indicated by the superior induration and partially scorched appearance of the *sienite* along its line of contact with the *basalt*.

The following sketch represents the appearances here described :—



A—The main rock of the bed and bank of the river, *sienitic granite*.

B—The *basaltic vein*.

C—The *hornblende vein*.

D—The bed of the river.

a. b. c. d.—Fragments of the main rock, containing portions of the *hornblende vein* evidently forced upwards.

e. e.—Other fragments of the main rock, without the *hornblende vein*.

II.

ON THE
G E O L O G Y
OF A PORTION OF
B U N D E L K H A N D, B O G H E L K H A N D,
AND THE
DISTRICTS OF SÁGAR AND JEBELPUR.

By. CAPTAIN JAMES FRANKLIN,

First Bengal Cavalry, M. A. S.

(READ FEBRUARY 11, 1828.)

HAVING lately had an opportunity of examining the Geological features of a portion of the provinces of *Bundelkhand* and *Boghelkhand*, and also of the districts of *Ságar* and *Jebelpur*, I have great pleasure in submitting the result of my observations to the Asiatic Society, and I beg to offer to their notice, the *lime-stone* formation, which is found on the summit of the second range of hills, as it appears to correspond with the *lias lime-stone* of England, and I am not aware, that this formation has heretofore been shewn to exist in India.

The tract of country to be here described, is a portion of the northern steps of the *Vindhya* mountains; for, although the ranges of hills
have

have separate names, such as *Bindáchal*, *Bandair*, *Kymur*, &c. which serve for local distinction, yet viewing them as Geological portions, they must necessarily merge in the common denomination of that great zone of which they are component parts.

I commenced my route at *Mirzapur*, a place of considerable traffic on the river *Ganges*, and ascended the first range of hills at the pass of *Tára*. The tract between these two places is not interesting in a Geological point of view, being covered with alluvium, which either reposes upon beds of *kankar*, or is intimately intermixed therewith, and near the hills, the *kankar* is found by the excavation of wells, to repose on *sand-stone*.

The first range of hills is composed entirely of *sand-stone*, horizontally stratified, consisting of fine grains of *quartz*, cemented by clay, and coloured more or less by the *red oxide of iron*; it is occasionally compact, but its general character is rather friable, than compact, and it sometimes contains galls of clay: it is also saliferous, as is evident from the plains below being saturated with salt, and also from the salt works, on the banks of the *Tons* river; in many parts, it has sufficient cohesion for architecture, and is quarried near to the *Tára* pass for that purpose: connecting these circumstances, therefore, and a comparison of it, with specimens of the same rock from England—it appeared to me to correspond with the new *red sand-stone*.

From the crest of the *Tára* pass, to the foot of the second range of hills near *Kattra*, the whole tract is a platform, varying only from a perfect level, by occasional protrusions of the rock, which form small collines, and sometimes hills; this platform increases in elevation towards the south-west; in the part where I passed, except immediately on the crest of the hills,

common

common *kankar* is very prevalent, either intermixed with the alluvium, or in beds, as in the channel, and on the banks of the *Bailan nadi* at *Baronda*, where it appears to be indistinctly stratified—and contains fragments of *sand-stone*: this part of the range is not rich either in minerals or metals; but another portion of it, near *Pannah*, is remarkable for containing diamonds, and still further west, are the extensive iron mines of *Katola*.

I ascended the second range of hills at the pass of *Kattra*, and found near the top of it a stratum of *red and bluish green slaty marle* interstratified with *sand-stone*, in thin laminæ, and surmounted at the top by variegated *sand-stone*; these beds resembled the *red marle* of England, and in furtherance of the conjecture that they may be so identified—I will add that salt is manufactured in the village of *Kattra*. The *slaty marle* rested upon massive beds horizontally stratified, resembling, as far as I can judge from description, Dr. MACCULLOCH's lowest *sand-stone*, 2d Div. F. the upper part of which was *schistose*, containing a little *mica* and tinged slightly *green*, but the lower part was massive, and coloured by the *brown oxide of iron*.

The summit of the second range is a platform, like the former, varying only from a perfect level by the same description of undulation which I have described above; like the former also it increases in elevation towards the south-west, and in order to examine its composition, I visited all the water-falls between the *Kattra* pass, and the *Tons* river.

The first of these cataracts is near the village of *Bilohi*, about twelve miles west of the pass of *Kattra*, the fall of water is three hundred and ninety-eight feet, and the escarpment is nearly perpendicular, the lowest bed is a thin stratum of fine argillaceous *sand-stone* tinged deeply by

the red oxide of iron and containing mica disseminated in small particles; upon it reposed a bed of siliceous sand-stone, tinged green, and intercalated with slate clay, or shale, of the same colour; these beds were compact and hard, but upon them was a thick stratum of variegated sand-stone, having an argillaceous cement, which continued to the surface.

From the cataract of *Bilohi*, I proceeded to that of *Bouti*, ten miles further west; this waterfall is exceedingly picturesque, not so much from the fall of water, which is four hundred feet, as from the extent of the cirque; the lowest rock is greenish white arenaceous sand-stone, not quite so compact as that of *Bilohi*, though, perhaps, it may be a continuation of the same, and upon it, (commencing at the depth of three hundred feet below the surface), is a variegated or mottled stratum, then follows a lilac red, or purplish stratum, which becomes more and more light coloured, so as to approach salmon colour, before it reaches the surface.

The enormous masses of *kankar* which have been rolled down by torrents into this chasm, are very remarkable; the surrounding fragments of sand-stone, are all worn, or their edges rounded by the attrition of water; but these masses remain unaffected, and continue to defy both the force of the stream, and the ravages of time.

From *Bouti*, I proceeded to *Keuti*, twenty-four miles further west; here the fall of water is two hundred and seventy-two feet, and the depth of the escarpment three hundred and twenty feet: the lowest stratum of rock is the variegated or mottled sand-stone mentioned above, and upon it reposes the lilac red; or purplish stratum, which last, commencing at the depth of two hundred and fifty feet, continues to the surface, varying only in consolidation, and becoming lighter in colour.

From

From *Keuti*, I proceeded to the cataract of *Chachai*, where the fall of water is three hundred and sixty-two feet; but here is no other rock than the lilac red, or purplish stratum, which varies as at *Bouti* and *Keuti*, both in colour and consolidation as it approaches the surface.

From *Chachai* to the cataract of the *Tons* river, is a short distance; the volume of water is greater than in the other cataracts, but the fall is less, being only two hundred feet, and the rock resembles that of *Chachai* so exactly, that it needs no further description.

These cataracts, though there is nothing stupendous about them, have still enough of interest to recommend them to the notice of travellers, and they have the advantage of being easily approached; they are sufficiently magnificent to occasion a slight impression of awe mingled with pleasure, at first sight, and this feeling is perhaps enhanced, by coming on the brink of the precipice almost unawares; they are also very picturesque, and deserve the talents and skill of an able artist.

In a geological point of view, they are more interesting, for, from their composition, it is evident, that the whole range of hills in which they are situated, is a mass of sandstone, they shew also, that there is a valley in the subjacent strata in this part, by exhibiting distinctly the plane of inclination of the variegated stratum, which being uppermost at *Bilohi*, central at *Bouti*, lowest at *Keuti*, and disappearing below the surface at *Chachai*, plainly denotes a subsidence, the axis of which is, perhaps, somewhere about the *Tons* river, and this appears to be the thickest part of the formation.

From the cataract of the *Tons* river, I proceeded via *Simmeriya*, *Birsinhpur*, *Hat,hi*, *Sohawel*, and *Nagound*, to *Lohargong*, and met with no other

other rock than *sand-stone*, sometimes ferruginous, sometimes slaty, and sometimes containing *mica*, until I arrived at *Hat,hi*, where it changed to argillaceous lias *lime-stone*.

At *Birsinhpur*, in the bed of the small river which runs near the town, is a stratum of *red marle* or *sand-stone*, containing laminae of *calc-spar*, distinctly interstratified; at *Sohawel*, red marle underlies the *lime-stone* above-mentioned; at *Nagound*, in the bed of the *Omeron* river, its lower and central beds are exposed to view, containing fragments of fossil wood, also fragments of stems of ferns, and one piece exhibited, what I took for an impression of the gryphite shell, which is peculiar to this formation; at *Marhar*, near the tank of the old village, it reposes on red marle, in conformable stratification; and at *Lohargong*, the wells of the cantonments exhibit its upper or slaty beds, reposing upon smoky grey *lime-stone*.

From *Lohargong*, I proceeded, via *Mehewa*, *Ghysabad*, *Hattah*, *Narsinhgerh*, and *Patteriya*, to *Sagar*.

The first part of the route, was over an alternating succession of *lime-stone* lowlands, and *sand-stone* collines, which continued as far as the *Kén* river, the bed of which is *red marle* and *sand-stone*; afterwards, the same alternation occurred to *Hattah*, where the *lime-stone* reposes on red *marle*, in the banks of the *Sonar* river, as it does also at *Narsinhgerh*, in a small ravine north of the fort; but there the *marle* is almost entirely green. At *Patteriya*, it comes in contact with *trap* rocks, and is thereby changed both in appearance and nature; those portions which contained most *silex*, are converted into *chert*, and it is curious to see specimens, one half of which is *chert*, and the other half still retaining the property of effervescing with acids.

The general aspect of this *lime-stone* is dull and earthy; its stratification is horizontal, or nearly so, and always conformable to the *marle* or *sand-stone* on which it reposes; its lower beds are thin, and separated by argillaceous partings; and some portions of it, particularly the white variety, are sufficiently compact for Lithographic purposes: the middle beds are usually of a dark smoky grey colour, always exhaling a strong argillaceous odour when breathed upon, and sometimes containing fragments of petrified wood, and of the stems of ferns, as may be seen at *Nagound*; and it is this variety which burns into strong *lime*, and has the property of hardening under water: the yellow kind is generally compact, usually dendritic, and if polished like the *Cottam* marble, might be used for ornamental architecture; its external surface frequently presents branches and prominences, resembling (as Mr. GREENOUGH expresses it) the interlacings of ivy, and in this state it might be used for rustic architecture.

This *lime-stone* appears to be the same as the *lias lime-stone* of England, and the specimens I send herewith, shewing its ordinary varieties, will enable the Society to judge how far my conclusions are well founded. It extends all over the platform of the second range of hills, covering it with a thin stratum, the continuity of which is only interrupted by occasional protrusions of the red *marle* or *sand-stone*, on which it reposes, and as these *sand-stone* collines are generally sterile, from want of soil to cover them, the *lias* formation becomes an object in agriculture, because it occupies the low lands, which retain moisture, and are covered with rich soil.

After passing the town of *Pattariya*, I came upon the overlying rocks, which I designate by the general term of *trap*; the hills on the left of the road are composed of those rocks, and after ascending the pass of *Patteriya*, I met with no other rock than *trap*, between it and *Ságar*.

The upper part of the *trap* of *Ságar*, like that of *Patteriya*, is frequently globular; the nuclei of the decaying masses varying in size from an egg, to a large bomb-shell; and their decomposing concentric lamellæ, being generally very thin, and often very numerous; the best specimens are too heavy to send, but that which accompanies this paper, will perhaps serve to explain my description.

Under the stratum of globular *trap* which usually occupies the highest part, is a bed of indurated *wacken*, or amorphous *trap*, of a rusty brown colour; sometimes scoriform, or of a small cavernous structure, and sometimes columnar; but this last form I have only observed in the beds of streams, or on the borders of the formation; under the amorphous *trap* is a stratum of *lime-stone*, white as chalk, which is observable at *Ságar*, and in the hills near *Pattariya*.

I have termed this white rock earthy *lime-stone*, because I know not what other name to give it; its principal component is carbonate of *lime*, and next to that is *alumine*; it also contains *silex*, and when it abounds, the rock is converted into *chert*: *felspar* does not seem to be abundant, and though the rock occasionally assumes the texture of indurated *clay*, and sometimes, though very rarely, the hardness of *clink-stone*, yet, generally speaking, it appears as if partially calcined, and when the *trap* with which it is associated reposes on *sand-stone*, as is the case in the district of *Ságar*, it contains nodules of *sand-stone* imbedded in it; the accompanying specimens exhibit its most ordinary changes above the surface; but several wells have been dug at *Ságar*, and its changes below the surface are shewn in a second series, sent herewith, one of which appears to be almost pure *alumine*; a thin *jaspery* stratum sometimes intervenes between the *wacken* and the *lime-stone*.

Below the *lime-stone* at *Sagar*, is a stratum of *amygdaloid*, containing *calc-spar*, and a few *zeolites*, which resembles the *toad-stone* of England; it there reposes on *sand-stone*, but I have not met with it *in situ* in any other part except some indistinct vestiges near *Jysinhnagar*, nor can I state, upon any authority, that the position here described, is applicable elsewhere.

From *Saugor*, I proceeded southward, via *Jysinhnagar* to *Tendukaira*, and met with no other rock than *trap* (with abundance of *chalc-dony*, *semiopal*, mealy *zeolite*, *cacholong*, *agates*, *jaspers*, and *heliotrope* strewn upon it,) until I descended the range of hills which forms the northern barrier of the valley of the *Narmada* river.

This great valley is favourable for throwing light on the primitive rocks of the central chain, where the force of receding water appears to have swept away the upper, and exposed to view the lower and older strata; many inferences may hereafter be drawn from a careful examination of this valley, but it would be premature to hazard any conjecture at present. I will, therefore, only observe, that the whole mass of overlying rocks which I have just passed, reposes on red *marle*, or *sand-stone*, as is apparent in the bed of the *Barana* river, about one mile north-east of *Tendukaira*, and all along the foot of the hills in that direction.

Its associate, the earthy *lime-stone*, here ~~is a hard rock~~ which generally appears half calcined; but its property of effervescing with acids is not destroyed, except in a few instances where it has become highly indurated; it fuses readily with a moderate heat, and operates as a flux when mixed with clay; and in this part, it almost always contains fragments of *sand-stone*, which are more or less changed by its contact.

After descending the hills, and advancing about three miles into the valley, a new field opens ; the older rocks are laid bare and exposed to view, and instead of horizontal stratification, they become highly inclined, sometimes perpendicular, and altogether unconformable to those which I have just passed ; I shall not here mention the *iron mines of Tendukaira*, because a satisfactory account of them would swell this paper too much ; but I will observe one circumstance which may, perhaps, be acceptable to travellers—the conical hill, situated about one mile and a half westward of *Tendukaira*, is an isolation of *trap*, and its summit was once crowned with a cluster of *basaltic* columns of a greyish green colour ; but some violent effort of nature, such as an earthquake, has dislocated them, and they now, even in their ruins, present an object worthy of the notice of a traveller.

From *Tendukaira*, I made a détour to *Garha Kota*, to meet the Agent of the Governor General, and my route thither enabled me to lay down the eastern boundary of the *trap* formation ; a reference to the map, therefore, will best explain the result of this part of my route. I always found the *trap* in association with earthy *lime-stone*, and the whole series reposing upon red *marle*, or *sand-stone*.

From *Garha Kota*, I returned to Great *Deori*, and proceeded across the *Bandair* hills to *Jebelpur*.

After quitting *Deori*, the rock was *trap* for about three miles, and then commenced the *sand-stone* of the *Bandair* hills, which continued uninterrupted, until I descended the eastern escarpment of those hills, which again brought me into the valley of the *Nermada* river.

The *sand-stone* of the *Bandair* hills, is mottled (red, speckled with white spots or streaks), its stratification is horizontal as far as the eye can

can judge, and it appears to correspond with the *bunter sand-stein* of WERNER, and, consequently, with the new red *sand-stone* of England; the same hills are composed of the same *sand-stone*, opposite to *Nagound*, *Lohargaon*, *Tigra*, and *Ghysabad*, and there can be no doubt that the whole is a mass of the same kind of *sand-stone*, varying, perhaps, in appearance, but not in character; and it would be interesting to examine whether there are any traces of an *oolitic* formation on their summits.

After proceeding about three miles into the valley, I came upon the ridge of the *Kymur* range of hills, which here begins to break, and soon disappears below the surface; in this part it is composed of silicious *grit-stone*, which evidently passes under the sandstone of the *Bandair* hills, but to the south-west of this point, near *Hirapur*, the rock becomes more compact, and still further west, opposite *Gúgri*, it is intermixed with *schistose* limestone, which contains *mica*, and, perhaps, green *talc*.

Between this range and *Jebelpur*, is a broad valley, covered by a thick stratum of *alluvium*, which required much more minute investigation than my hurried route enabled me to bestow.

The town of *Jebelpur* is situated at the foot of a range of *granite* hills, which, perhaps, might be termed *syenitic granite*, as its composition is flesh-coloured *felspar*, smoky *quartz*, a little black *mica*, and much *horn-blende*. I have traced it for thirty miles, in which space it dips below, and rises above the surface several times, and there the rock becomes well defined *granite*, and is particularized by its tendency to exhibit *logging-stones*: it is much subject to decomposition, from the quantity of *felspar* it contains.

Every formation subordinate to *granite* is to be found in this neighbourhood. Gneiss, containing *hornblende*, and partially decomposed, so

as to acquire a *ligniform* appearance, is in the bed of the *Nermada* river, at *Tilwara* Ghat; *Mica-schist* is at *Ramnagar*, and all along the low range of hills, which runs from thence towards *Lamaita*. *Hornblende-schist* is in the hills, between the villages of *Bhowra* and *Pareri*; *talcose*, and *argillaceous-schists* in the hills between *Bhowra* and *Maroud*, and in the bed of the river between *Lamaita* and *Beragarh*, a series of strata are laid bare, exhibiting *gneiss* at one extremity, and from it, a regular gradation of *micaceous* and *argillaceous-schists*, to schistose limestone, *quartz-rock*, and the beautiful snow-white *dolomite*, which is described in the following paragraph. I cannot here omit to recommend to any traveller, desirous of observing these strata, to walk along the edge of the river from *Lamaita*, to the water-fall of *Beragarh*, from whence he may either proceed in a canoe, through a narrow channel, excavated by the torrent, and enjoy a spectacle, far exceeding any description I can give of it, or he may return by the ruins of *Trípurapuri*, which are near the village of *Teor*, and examine the remains of the ancient capital of *Garha Mandala*.

The *Dolomite* is near the water fall; it has been called *muriacite* and *alabaster*, both of which it resembles; but from its geological connections, as well as its composition, it is evidently a *dolomite*, and its most refractory portions, if pulverized, will effervesce, with diluted *nitric*, or *muriatic acid*; a few miles further west, it effervesces freely, and is friable, almost crumbling between the fingers, and contains crystals of *Tremolithe*; but at *Beragarh*, being intimately associated with *quartz-rock*, it contains more or less *silex*, and the snow-white variety, which resembles *alabaster*, seems to be an aggregate of *dolomite* and pure *quartz*: this variety scarcely effervesces without being pulverized, but it takes a fine polish, and is quarried for various purposes, such as slabs for floors, or tables, and it might well be used for ornamental architecture, or even for statuary: it is traversed, in many parts, by veins of *chlorite schist*.

From

From *Jebelpur*, I returned to *Tendukaira*, by another route along the metalliferous range of hills, which it was my business to examine; but I refrain from giving any account of its mines, for the same reason which I have alledged in my account of *Tendukaira*. I must also defer sending a map of this portion, which I have constructed on a larger scale, in order to shew the position of the mines, until a future opportunity; in the mean time, I may observe, that a part of the southern barrier of the valley of the *Nermada* river (like the northern, opposite to *Tendukaira*, *Sirmow*, &c.) is composed of *trap* rocks, the contour of which I have laid down to the extent of eighty miles, and I trust, that a future opportunity will enable me to complete the whole.

The result of my inquiries respecting this eastern deposite of overlying rocks, is, that it extends southward, as far as *Chaparah*, or *Seoní*, and thence eastward, towards *Mandela*, *Amerakantak*, and *Sohagpur*; but whether it unites with the great central mass, I could not learn; it is somewhat harder than the *trap* of *Ságar*, but does not essentially differ from it in character, as the accompanying specimens will shew; but it differs greatly in its substratum, which is here *granite* or *gneiss*.



In the re-entering angles of the *trap* hills, the occasional re-appearance of the primitive range may be traced, and in a cluster of such hills, about one mile south of *Bograi*, the rock is composed of *mica*, *quartz*, compact *felspar*, and *chlorite*, intimately intermixed in fine grains, and somewhat friable; in the same hills also, is a conglomerate of the same formation, containing *quartz-pebbles*, much rounded, and worn by the attrition of water, but no fragments of *green-stone* or *basalt*, although the hills in question are nearly surrounded by rocks of the *trap* family.

After

After passing *Bograï* the valley expands, and is covered by thick alluvium, through which the *dolomite* occasionally crops out for a short distance ; but with that exception, no rocks appeared above the surface, until I arrived at *Kshirarpani*, where the hills are composed of stratified *quartz* rock, sometimes granular, but more frequently compact, and containing *felspar*, the strata are highly inclined, and sometimes perpendicular, and as there is no other kind of rock, between *Kshirarpani* and *Tendukaira*, except the isolated sandstone hill of *Amjero* : this brings me back to the *sand-stone* and *trap* formation of the *Ságar* district.

To this catalogue may be added a very curious calcareous conglomerate, which is found in the beds of most rivers, whose sources, or whose channels are in *trap* countries ; I have observed it in the bed of the *Sonar* river, north of *Reili*, and in other places ; it occurs also plentifully in the *Nermada* river in various parts ; but the largest mass I have seen of it, is near the *Jansi* Ghat.

It is composed of rounded fragments of *wacken*, *basalt*, sandstone, *quartz*, and occasionally of other rocks, varying from the size of a pea, to that of an ordinary grain of sand, cemented by calcareous matter, and when the particles are fine, the rock in some respects resembles calcareous *sand-stone*, and has sufficient cohesion for architectural purposes ; its stratification is always horizontal, the coarse parts being lowest, and it reposes on the subjacent stratum, be the rock what it may, for it is evidently the latest formation ; thus at *Beragarh* it may be seen in the high banks of the river, reposing upon the primitive strata, and itself covered only by alluvium to the depth of thirty feet.

I have not met with a description of this rock by any author, and yet it cannot be considered strictly local, for it is evidently a conglomerate, formed

formed from the detritus of *sand-stone*, and overlying rocks, which appear to be its chief constituents, and, consequently, must be of considerable extent in this country.

Having thus given a description of my route, and a brief compendium of my observations as they were made on the spot, I will now venture a few general remarks on the conclusions I have drawn from them, and should I inadvertently lean to either side of a disputable question, I intreat that it may not be attributed to design : I am not learned enough in the science to become an advocate for any party : a few lessons when in England, and the great volume of nature have been my chief guide, and to record facts, to lay down strata correctly, though not minutely on a map, to extract that which is useful or profitable in the science, is all I aim at, and the train of investigation which this requires, imperceptibly leads to an acquaintance with books, which gives facility of discrimination and description, even though the depth of the science may be wanting.

The late Dr. VOYSEY observed, "that he had reason to believe, partly from personal observation, and partly from specimens obtained from other sources, that the basis of the whole peninsula of India is *granite* : he had traced it along the coast of *Coromandel*, lying under *iron-clay* ; also in the bed of the *Godaveri* river, from *Rájamahendri* to *Nandair*, and he had specimens from the base of the *Sítábalá* hills of *Nagpur*, from *Trávankur*, *Tinnevelli*, *Salem*, and *Bellari*;" to this may be added Mr. STIRLING's account in his memoir on *Cuttack*, where he says, "the *granite*, where my specimens were principally collected, appears to burst through an immense bed of *laterite* (*iron-clay*), rising abruptly at a considerable angle." These are recorded facts on the southern side of the central chain, and on the northern side, it may

be observed, that the plains of *Bundelkhand*, attest that *granite* is there the basis rock.

Though I am convinced that *granite* is very near the surface, in many parts of the tract which has fallen under my observation, yet it is evident, that there is a series of primary stratified rocks, intervening between it and the secondary formations, as in other parts of the world, though there is reason to think that they are often wanting; the flanks of primitive ranges of hills almost always exhibit a series of these rocks, and as an instance, I refer to that which is laid bare in the bed of the *Nermada* river, between *Lamaita* and *Beragarh*, these strata are not intermixed, they present a series of beds from *gneiss* upwards, each in its place, graduating one into another imperceptibly, and all preserving the same dip, direction, and parallelism, without any tendency to derange each other, and they are found on the spot, where the river intersects the primitive range of *Jebelpur*.

In this part of India, however, the primary formations are so extensively covered by secondary and overlying rocks, that vallies of denudation alone expose them to view; and under that impression I observed in a former paragraph, that many inferences may hereafter be drawn from a careful examination of the valley of the *Nermada* river, and I may also add, from a careful examination of all great vallies of denudation, which, like that of the *Nermada* river, exhibit a view of the primary strata, by removing the superincumbent beds under which they were buried.

The *sand-stone* formation is the next which attracts notice; its thickness is, of course, variable, it is four hundred and twenty feet, at the *Bout* cataract; and from the compactness of the rock, at the bottom of that water-fall, I am disposed to think that it does not extend far below; there

can be no doubt, however, that it is thicker near the *Chachai* and *Tons* cascades, and the *Bandair* hills must be still more so; it appears to comprise most of the varieties of Dr. MACCULLOCH's synopses of lowest and some of his superior *sand-stones*, whilst the general parallelism of its stratification to the horizon, and its saliferous nature, well enough identify it with the new red *sand-stone* of England, which comprises all those beds that lie between *lias lime-stone* and the coal measures.

The *lias lime-stone* formation is exceedingly curious, for, whilst in other countries it forms mountainous tracts, and occupies extensive portions of the earth's surface, it is here a mere plastering over the surface of red *marle* or *sand-stone*, and I should doubt whether it ever attains the thickness of a hundred feet. I have not met with it in any other place than on the summit of the second range of hills, and it may there be seen in the low lands, and in the beds of small rivulets, but in the large rivers it appears to have been swept away, as their channels are worn down to the subjacent *sand-stone*, and perhaps, in some cases, to the primitive strata.

The overlying *rocks* of the *Sagar* district appear to be the *flötz-trap* of WERNER; they are not only the most extensive, but, considered as *geological phænomena*; they are the most important in that district, and, perhaps, in India. The prevalence of opinion regarding their origin is now, indeed, inclining to a modified volcanic theory, and as their extent is truly astonishing, I feel persuaded, when their correct outline shall have been ascertained, that the representation alone will be correspondently striking. As far as my observations have extended, I have never been able to reconcile my ideas of it, to the *Wernerian* theory alone; I have seen it meandering round isolations of *sand-stone*, and resting against them in a manner which could not have occurred, had its origin been such

• such as is described in that theory, without covering the *sand-stone* also. Its known effects on other rocks, which come in contact with it, are also striking circumstances ; but as India possesses advantages over all other countries in the investigation of this subject, it would be premature indeed to draw inferences before we are in possession of the facts, which alone will enable us to arrive at a satisfactory conclusion. The thickness of this formation we have it not in our power to obtain, as it is constantly variable ; in the centre of India, it occupies the summits of the highest mountains, and at *Bombay*, it descends to the level of the sea ; it reposes indiscriminately upon every rock, from *granite* upwards, and it is quite impossible to fix on any average : it is useful, however, to find out the rock, on which it reposes, and its inferior level in the tract under examination ; thus, for instance, at *Ságar*, it reposes on *sand-stone*, and its inferior line, in that district, is about 1350 feet above the sea, and as this is also the superior limit of *lias*, it follows, that the *trap* of *Ságar* is unequivocally posterior to *sand-stone*, and may be either just previous to, or contemporaneous with, or posterior to *lias*, the latter of which, I apprehend, will be found to be the case.

There are two kinds of *basaltic* rocks in the district of *Jebelpur*, which are clearly distinct formations ; the oldest variety is that which penetrates the *graywacke* stratum in the bed of the *Nermada* river, near the village of *Lamaita*. This stratum, though not above fifty yards thick, is intersected by innumerable *green-stone veins* and *nodules*, always running in the direction of the strata, and as they do not occur in any of the adjoining formations, they must, I presume, be at least as old as that rock ; the other *basalt* is an overlying rock, like that of *Ságar*, but it reposes on *granite* or *gneiss*, instead of *sand-stone*, and appears to contain a greater proportion of *augite*.

The calcareous conglomerate must be classed, in point of time, at least with the *tufas*, and other calcareous formations, such as common *kankar*, so prevalent in India: it is generally admitted, that these substances have been deposited from water, in rapid motion, holding the matter in solution, and under circumstances unfavourable both to crystallization and regular deposition, and it has sometimes occurred to me, that the matter of which they are composed, may, in other countries, under more favourable circumstances, have been deposited in regular beds and strata, such as the *oolitic* formation of England; and I am the more inclined to think so, from finding the *lias* stratum so thin; also from its upper *slaty* beds being in general wanting; and further, from not having hitherto discovered any traces of a regular *oolitic*, or any later regular formation.

The great extent of *trap* rocks, being nearly equal to a third of the area of the country, and the absence of all regular formations posterior to *lias*, if future research should prove it to be the case, are undoubtedly remarkable features in the geology of India; and I cannot help thinking that they may, hereafter, be the means of explaining some of the most important phenomena in the science, provided the facts of the case are well and justly ascertained.

Barometrical observations made on the route from *Mirzapur* to *Ságar*, and thence to *Tendukaira*, and *Jebelpur*, with heights above the sea deduced therefrom, together with the Latitudes and Longitudes of the respective places.

DATE.	PLACE.	BAR.	TEMP.	HEIGHT.	LATITUDE NORTH.	LONGITUDE EAST.
1826					° ' "	° ' "
November. 21	Lalganj,	29 56	69	504 feet	21 1 25	82 18 25
25	Barounda, ..	.....	.....	.....	24 57 20	82 14 00
26	Kattra,	29 57	70	520 feet	24 53 20	82 6 30
27	Hannanna, .	28 79	68	1219 "	24 46 15	82 4 15
28	Bilohi fall, ..	28 89	68	1128 "	24 48 45	81 57 15
29	Bouti fall, ..	29 04	71	1000 "	24 46 40	81 49 20
30	Gerh,	29 00	71	1036 "	24 49 15	81 39 50
December 1 & 2	Keuti fall, ..	29 12	70	923 "	24 49 15	81 27 00
3	Chachai fall,	29 05	70	990 "	24 48 0	81 17 20
"	{ Tons fall, deduced } { from the same, .. }	.....	.....	890 "	24 47 15	81 15 05
4	Simeriah,	29 04	72	1000 "	24 48 34	81 8 55
5	Birsinhpur,	29 00	76	1064 "	24 48 30	80 57 20
6	Hathi,	28 99	74	1070 "	24 43 18	80 49 15
7	Sohawel, ...	29 00	73	1059 "	24 34 27	80 46 40
8	Nagound,	28 97	75	1099 "	24 34 21	80 35 25
9	Girwar, ...	28 85	77	1216 "	24 33 0	80 25 30
10	Lohargaon,	28 80	75	1251 "	24 31 15	80 19 00
"	Ditto above Calcutta, .	.....	.....	1231 "		
11	Mehewa,	28 86	72	1181 "	24 24 20	80 7 25
12	Tigra,	28 94	70	1093 "	24 18 20	79 59 05
13	Garreho,	28 90	71	1131 "	24 15 38	79 40 35
14	Hatta,	28 86	74	1183 "	24 7 45	79 35 10
15	Narsinhergh,	28 71	72	1314 "	24 1 08	79 24 20
16	Bikairi,	28 76	70	1263 "	23 53 02	79 13 10
17	Saipur,	28 57	70	1412 "	23 53 15	79 2 30
18	Pareneah,	28 54	68	1644 "	23 51 30	78 56 10
19 to 31	Ságar, (tent)	28 10	77	1933 "		
	Ditto above Calcutta,	.....	.....	1926 "		
	Ditto Town, .....	.....	.....	1940 "	23 50 30	78 44 00
	Ditto Cantonments, .	.....	.....	1980 "		
	Ditto Residency, ...	.....	.....	2050 "		

DATE.	PLACE.	BAR.	THER	HEIGHT.	LATITUDE NORTH.	LONGITUDE EAST.
1827						° ' "
January 4	Jysinhnagar,	28 00	60	1913 feet	23 37 12	78 33 30
Morning 5	Garraah,	27 00	71	2094 "	23 30 17	78 39 00
Evening 5	Tandah,	28 10	61	1851 "	23 23 37	78 41 40
January 6	Ghano,	28 30	74	1724 "	23 22 55	78 49 45
Evening 6	Schajpur,	28 50	71	1515 "	23 17 50	78 53 30
7 to 10	Tendukaira,	28 70	75	1338 "	23 10 40	78 58 30
19	Dohi,	28 32	75	1704 "	23 17 12	79 04 55
21	Gt. Deori,	28 30	70	1705 "	23 24 18	79 04 50
22	Chandpur,	28 45	74	1575 "	23 34 21	79 06 15
23 to 24	Gara Kota,	28 60	67	1345 "	23 47 25	79 07 30
25	Reilli,	28 00	60	1350 "	23 38 50	79 03 45
26	Rangir,	28 47	66	1522 "	23 37 45	78 55 20
27	Chandpur, vide above,					
28	Gt. Deori, vide above,					
29	Kúsiari,	28 47	79	1584 "	23 23 48	79 11 55
31	Byusa,	28 67	81	1394 "	23 24 38	79 20 00
February .. 1	Sannapur,	28 51	79	1546 "	23 19 45	79 25 00
2	Patteriah,	28 67	81	1395 "	23 15 35	79 34 45
3	Natwara,	28 65	81	1426 "	23 10 30	79 40 20
4 to 10	Tcor,	28 64	75	1396 "	23 09 20	79 51 45
12 to 18	Jehelpur,	28 60	81	1458 "	23 10 40	79 58 15
	Ditto Cantonments, ..			1470 "		
	Ditto Residency,			1500 "		
19 to 20	Pannagerh,	28 58	80	1477 "	23 19 15	80 02 30
21 to 22	Pouri,	28 62	76	1423 "	23 23 00	80 08 50
23 to 24	Majgowa,	28 52	84	1550 "	23 24 15	80 11 30

NOTE.—From the 24th of February, and throughout the whole of the month of March, and part of April, the weather was very unsettled, raining at intervals, and this unsettled state was followed by great heat in May and June, which became excessive in the beginning of July. The Thermometer at Tendukaira ranging from 120° to 122° in the sun, and from 108° to 110° in the shade, which rendered Barometrical observations for height, too uncertain to be relied upon.

A P P E N D I X.

THE barometrical observations of the accompanying table were in every case, not particularised, derived from a mean of several during the day, and sometimes as at *Ságar*, *Tendukaira*, and *Jebelpur*, from a mean of several days; the mercury of the barometer was taken out, the tube cleaned, and fresh mercury purified by Mr. Prinsep, of *Benares*, substituted at that place; after which it was compared with his barometer, and as a check upon it, I used a box barometer of Sir H. Englefield.

It was constantly hung up in my tent, and the detached thermometer suspended in the shade in the open air, and I always waited, until the attached thermometer agreed with that which was detached, or in other words, until the quicksilver of the barometer had acquired the temperature of the air; so that one thermometer was sufficient to register.

My method of calculation is that of Dr. Hutton, checked, indeed, by that of Dr. Robinson, but never altered, because the results were nearly equal, and my point of reference and comparison was a station of the grand trigonometrical survey at *Ságar*, which is 2195 feet above the level of the sea.

I, ascertained by measuring a base line, that this station was 250 feet higher than the tent where my barometer was placed, and a mean of fourteen observations gave 1933 feet for its elevation above the sea according to Dr. Hutton's method, $1933 + 250 = 2183$, differing only twelve feet from the geometrical result; and as I have used the same barometer and the same mode of calculation throughout—if twelve feet be added to each of the items of the table, they will, I conclude, be nearer the truth, because I have greater confidence in the geometrical results, than in those of the barometer.

The stations of the trigonometrical survey, afford an excellent opportunity of comparison and check, and provided they are referred to at moderate intervals, it matters but little what formula of calculation is used, if it is constantly the same, as the results cannot greatly vary, if the barometer is also the same, and the observations are carefully made.

The average height of the first range of hills between *Tára* pass and *Kattra* pass is about 520 feet above the sea; that of the second range, between the *Kattra* pass and *Lohargaon*, 1050, and between *Lohargaon* and the foot of the hills near *Patteriya*, about 1200 feet, gradually ascending.

The average height of the highest parts of the third range, or *Bandair* hills, ascertained geometrically from *Lohargaon*, *Tigra*, and *Garrho*, is about 1700 feet, and as they are the same, deduced barometrically at *Samaspur* and *Patteriya*, they are evidently a platform, like the first and second ranges, varying only from a perfect level by the undulations described in the account of them.

The junction of the *Sonar*, *Bearmi*, and *Kén* rivers, is about 1000 feet, ascertained from *Tigra* and *Garrho*; the source of the *Sonar*, is 1950 feet, and its fall 950 feet in a course of 110 miles; the source of the *Bearmi*, about 1700 feet, ascertained from *Samaspore*, and its fall to its junction with the *Kén*, 700 feet in 105 miles; the source and fall of the *Kén* river is nearly the same as the *Bearmi*, though its course to the point of junction is only seventy miles, but there is a cascade in this river at the *Piperiya* Ghat.

The highest line of *limestone*, is about 1350 feet, and the lowest near *Hat,hi*, about 1070. The lowest level of *trap* in the *Ságar* district, is near *Patteriya*, about 1350 feet, and its highest is the summit of the highest hills; of *sand-stone*, the highest level is in the vicinity of *Ságar* or *Raisen*, and its lowest the foot of the *Tára* pass; but these local levels have reference only to the tract which has fallen under my observations, and by no means apply generally.

The cantonments of *Lohargaon*, are about 1260 feet, those of *Ságar*, about 1980 feet, and those of *Jebelpur*, about 1470. The Residency of *Jebelpur*, is about 1500, and that of *Ságar*, about 2050 feet above the sea.

The latitudes have all been observed by myself, chiefly from meridional altitudes of the sun, when available, and when not, from observations of the stars, taken with a good sextant, by the method of reflection ; the longitudes are from a large map of my own survey.

With regard to the geological map, having previously surveyed a great portion of the *tract*, I may, with some confidence affirm, that the topographical features are accurate, and so also are the outline delineations of *trap* and *sand-stone*; the *lias* required a more minute survey than my time afforded : the outline of its extent is correct enough, but the *sand-stone* collines, which protrude through it are, in a great measure, conjectural ; and the primitive strata are comprised under one distinctive colour, as it would have required miniature minuteness to have delineated them, under separate heads ; the strata of *Beragerh*, for instance, comprise a series from *gneiss* to *dolomite* in a space of two miles, and a delineation of them would have represented a ribband, with all the colours of the rainbow, rather than a geological arrangement, in a map of so small a scale.

III.

THE TRAP FORMATION OF THE SAGAR DISTRICT,

*And of those Districts Westward of it, as far as Bhopalpur, on the
Banks of the River Newas, in Omatwara.*

By CAPTAIN S. COULTHARD,

Of the Bengal Artillery.

A GENERAL idea of the number of sand-stone hills, rising through the trap formation of the district about to be described, may be formed from the number of villages; for, although a few villages may be seen, situated on the slopes of trap hills, the natives, as far as possible, have avoided placing their habitations on rocks of this formation, and there being fully as many sand-stone hills, without villages, as trap with them, it may safely be said, that there are as many isolated patches of sand-stone in these districts, as there are villages.

At *Panchamnagar* and *Satpárah*, places marked in the accompanying sketch, there is the lias, and about nine miles west of those places, or at *Sanwa*, the trap and sand-stone. The same may be said of *Pattariya*
and

and *Garakota*, on the right hand, and *Shahpur*, one march on the left, or westward; and then, if a line be drawn between these places as respectively mentioned, leaving the nameless rivulet as it occurs between *Shahpur* and *Pattariya*, in the lias, and also continue this line southward to the red sand-stone hill, which overhangs *Tendukaira*, in the vale of the *Deorí*. there will be a tolerably correct eastern boundary given to the trap formation of *Ságar*.

The vale of the *Deorí* is of an older formation, than either the lias of the *Hattah* district, or the sand-stone subjacent to the trap of *Ságar*.

That red rock, which has been alluded to as skirting the *Deorí*, near *Tendukaira*, has its accompanying trap hills, and these, in their general direction, bend their course to *Hasanabad*; indeed at *Sírmow*, or soon after passing south of that place, the road from *Ságar* to *Hasanabad*, descends this trap range, and afterwards continues at their feet, on the south side, the whole distance to *Hasanabad*. Let it be added to this, that the road for fifteen miles south of *Hasanabad*, or as far as *Petraotah*, is on the alluvial matter of the *Nermada*, a deep black basaltic mould, and that at *Petraotah*, a hilly country again occurs, consisting of primary rocks, contingent on the granite of *Shahpur*, *Nimpání*, and *Bitúl*, and then there is a definite bounding line on the south.

If the cantonment of *Bhopalpur*, on the right bank of the river *Newas*, be taken as a point, and a line be drawn from that point to the *Nermada*, so as to pass between *Sultanpur* and *Dewas*, such line will cut through the eastern part of the trap formation, described by Captain DANGERFIELD, as that officer marks both those places in his sketch; indeed, that which is under description by me, is a mere continuation to the eastward of the newest floetz trap formation, named by that officer, as occurring

occurring in the upper plains of *Mahwa*, or to speak still more correctly as to direction, it is a shoot up north-eastward from it.

With regard to the northern line of demarcation, I cannot be so satisfactory and clear. If a line be drawn from *Bhopalpur* to *Seronj*, it will pass through the formation, under review, but as to how far this formation extends north of such a line, I have no precise information. The *Maltoun* pass is of sand-stone, and I believe this rock ends somewhere between the crest of the pass and the village of *Naret*, not far removed from its northern foot. The granite is at *Tiri*. An iron ore is worked to a considerable extent at a spot intermediate between *Dhamúni* and *Marowra*; *Dhamúni* has the trap and sand-stone; and the trap ceases five miles and a half south of *Hirapur*, whilst the bare sand-stone, freed from any overlying mass, continues until it may be seen resting on matter incident to the primary rocks, at *Hirapur*, and where, too, it ceases entirely. Nearly in this direction will be the northern limit of the trap formation, as laid down in the accompanying sketch, but much confidence is not to be placed in it; the boundaries, however, to the east, west, and south, may be offered as sufficiently accurate.

It is eighty-four miles from *Bhopalpur* to *Bhilsa*, and seventy-two from *Bhilsa* to *Ságar*, and twenty more bring us to *Shahpur*; and this line, though not a straight line, is sufficient to give a general idea of longitudinal extent. *Hirapur*, in the northern quarter, cannot be less than seventy miles distant from the southern boundary, given to the sketch; and the whole of this extensive area is occupied by the newest floetz trap formation of WERNER, subjacent to which is the new red sand-stone, shooting up frequently from below through the overlying rock.

It is a hilly tract throughout; but it may be better understood if it be said, that at *Ságar*, in its neighbourhood for eight or ten miles around, and also in every part south of *Ságar*, within the prescribed limits, and as far west as *Hasanabad*, may be seen ranges of low hills extremely clustered, though always detached, bending about in their short course towards all points of the compass, and thus forming valleys of every conceivable form, though not commonly of any great extent, and never difficult of access. But if the view be extended beyond the neighbourhood of *Ságar*, towards the east, or the west, or the north, expanded valleys will gradually meet the eye, whilst the hills recede from it sinking in the horizon as they surround valleys farther removed from *Ságar*, until these valleys are enlarged into extensive undulating plains, studded over with isolated trap hills, occasionally of a conical, commonly of no determinate form, whilst ever and anon, a short range of the same, deviating little from a straight line, will have its beginning, and its ending, within view.

These valleys and these extended open plains, are every where composed, near the surface at least, of a trappean or basaltic mould, blackish in color, which reposes either on a bed of basalt, or on a bed of compact wacken. This compact basalt, or compact wacken, is either of an uniform ovate form, or else it is in angular pieces of middling size, and underneath these, as their occurrence may respectively be, lies an amygdaloid decomposing and decomposed, and which, as a retentive clay, keeps up the water near the surface, and it is so met with throughout this tract.

As to the trap hills, there is no occurrence of a bold bluff escarpment belonging to them, their sides and ends are always sloping and rounded, and, as far as the angle subtended from the summit is concerned, of easy ascent. Their surfaces are thickly strewn over with masses of basalt or wacken, imbedded in a basaltic or wacke clay, and differing only in size
and

and form in different places, in a trifling degree. From one hundred and twenty to one hundred and fifty feet above the edge of the contiguous vale, may be said to be the general height of those that rise above the rank of swells and knolls, whilst a hummock, a cone, or something of a truncated cone, occurring in their otherwise even outline, and which serve to characterise them from their sand-stone companions, partially increases the elevation.

The sand-stone rock is very prevalent, as a mere mound or rise, constantly having a village upon it, and situated often on the plain ground, oftener on the edge of the plain ground, with a trap hill partly resting on it. In particular parts of the country, however, ranges of sand-stone hills occur, equalling, though never exceeding, in height and extent of range, those of the trap, whilst they are to be easily distinguished from them by their general evenness of outline; by their having vertical or precipitous escarpments at their ends, and on their sides to within twenty or thirty feet of the top; by the fallen masses lying about; by often sharply-defined, castellated, and mural appearances on their summits, and, in short, are to be distinguished by all that which has been remarked of them as exclusive, when occurring in other countries. They never appear interstratified with any other mineral, when they occur in the tract of country under review.

And these swells and hills of sand-stone and of trap, most particularly the former, may often be observed sterile and bare, shewing nothing but some coarse grass during the season of the rains, which gives to them, at that time, a tinge of green; but the vast majority of them are ever thickly cloathed with vegetation, consisting of plants, and shrubs, and forest trees of stunted growth, in particulars only differing from those of constant and every-where occurrence in India, and which have often been numbered
and

and described. And lastly, the flat and compressed surfaces of both kinds of hill, are often of considerable breadth, and on the summits of the trap hills, not those of the sand-stone, more especially in the angular parts of the trap hills, as they bend about, may be seen a patch or cultivated spot.

With regard to the general level of this land above the sea, I may observe that there is a peak shooting up from a trap range to the eastward of *Raisen*, which attains an elevation of something more than 2500 feet; but the hills of *Raisen* are much less, so also is the sand-stone range of hills on the north bank of the *Nermudá* at *Hasanabad*. *Ságar*, upon the whole, is the highest part in this tract. The centre of the cantonments at *Ságar* is 1983 feet above the level of the sea by the barometer, and the hill at the mint of *Ságar*, which is about a mile from the last named point, is something more than 2300 feet by trigonometrical calculation. I have before remarked, that *Ságar* and its neighbourhood is a confined hilly tract, and that towards the east, and the west, and the north, the country opens; and it is, in fact, taking *Ságar* as a radiating point, in those directions that the land opens that the general elevation of it above the sea decreases;—but not so much westward or towards *Bhopalpur*, as the general elevation of the upper plains of *Malwa*, is 1650 feet, and *Omatwara*, in which *Bhopalpur* is situated, belongs to those plains;—neither is it so much towards the lower lias formation of the *Hattah* and *Garakota* district, or eastward, because the elevations there are, in general, about 1500 feet. It is in the northern quarters that the principal, and a rapid diminution in height is to be observed, for the *Maltoun* pass, nearly due north of *Ságar*, and six and thirty miles distant, is only 1000 feet above the level of the sea, by trigonometrical calculation;—*Seronj*, to the westward of north from the same place, is 800, and *Hirapur*, to the eastward of north, between 1000 and 1100 feet, by the same calculation. From all this it is to be inferred, that the elevation
about

about the central point of *Ságar* is from 1800 to 2500 feet, and that in a northerly direction the land declines considerably,—and much more in that direction than it does towards the east or towards the west. In addition, if it be observed that the primitive range skirting the alluvium of the *Nermada*, south of *Hasanabad*, was found to be on a general equality as to height, with the trap and sand-stone rocks of *Ságar*, whilst the granite range of *Bundelkhand*, on the northern limits, is at least 1000 feet lower than those rocks of *Ságar*, a point nearly midway between the two-named primitive ranges, all is said, it is hoped, that need be, to assist the idea as to what is the general elevation above the level of the sea of the trap and sand-stone under review.

There exists so strong a family likeness between all the trap rocks of this formation, that it may safely be said, was chemical analysis resorted to, a nearly similar result would, in almost every case, be obtained. It is always every where an earthy homogeneous deposit, by which is to be inferred that there does not occur in it any rock of a definite, or nearly approaching to a definite, crystalline structure: neither a coarse-grained basalt will be found, nor a syenite, nor a green-stone, shewing distinctly its constituent simple minerals, nor is there indeed either a clink-stone or clay-stone. It appears as a closely allied family of basalts of a very fine grain, of wackens and amygdaloids, all others, of the long list of trappean rocks, may be thrown out of consideration, as of no alliance and of no occurrence here.

No. 1.—Of the few varieties there is one basalt which has been said* to be similar to the *Rowley Rag*, and it certainly does agree very closely with

* By Dr. VOYSEY, I believe.

with the description given of that mineral. Its colour is greyish-black, —its lustre is slightly glimmering, and it has a flat conchoidal fracture, and is difficultly frangible. It is not here the rock of most common occurrence, but I name it first, and marked it No. 1, because it is the hardest. It does not rise above the surface, but occurs in beds where the masses are of an uniform, egg-shaped figure, perhaps a foot and a half in their longest diameter, or it occurs in beds, where the masses are angular pieces, or cubes disfigured, not much exceeding a foot in measurement any way, and closely set together without cement.—It seems to be little liable to external decomposition, and its surface, which is smooth and entire, is coloured a yellowish white.

No. 2.—There is another basalt differing little from the last, except that it has not the same tenacity, and its colour is soot black. It occurs only in angular pieces. I mark it No. 2.

No. 3.—Is another in colour like the last, but still softer, and which splits, with a moderate blow, at natural joints, into small four-sided prisms, coated with a blueish coating, like that often seen on newly wrought iron. —It is in the mass amorphous.

No. 4.—Is a five-sided prism. When the bed of a rivulet or river is composed of angular pieces of basalt or wacken set together in a pavement-like form, the surfaces exposed to the double effects of intense heat and moisture, will appear cracked into a variety of prismatic forms, and occasionally it will appear such as No. 4.

All these rocks seem to be, though not wholly, yet essentially composed of an intimate mixture of felspar and hornblende in an earthy state; and the latter, or hornblende, is the mineral that characterises all the harder kinds,

kinds, whether compact or amygdaloidal, whether they are basalts or wackens, for their colour is black, or black, only slightly modified :—The structure is always massive,—a laminated specimen could not be obtained.

But the principal rock, throughout this formation, is that represented by No. 5. It is what is termed a compact indurated wacken, in colour black, with a very distinct brownish tinge. When first fractured, its surface has a much more glimmering appearance, than the basalt, but unlike the basalt, exposure to the atmosphere, soon changes its surface into an earthy dirty whitish colour. It is often very tough, very refractory under the hammer, but its fracture is flat and dull,—not sharp and splintery, or approaching to the conchoidal. It occurs in pieces, in length, breadth, and depth, pretty nearly the same, a foot in measurement, and which are set closely together, so as to form something like a stratum in the hills,—or in the vallies as the base of the basaltic mould; and it is also the predominating variety in those hills, which are of such constant and general occurrence, consisting of large rounded and angular masses, thrown up together in the utmost confusion, with very little clayey matter intermixed; and lastly, it may often be seen abstracted and alone, in something like large uniformly ovate masses, having a brownish and wrinkled exterior, and imbedded in a sombre reddish brown clay No. 5, is taken from a hill of the last kind.

No. 6 will exemplify the same where set as a stratum.

No. 7 is also the same kind of wacken, but it is decomposing with a nucleus of undecomposed black matter, and the superficial and decomposing part is a light yellowish brown;—further stages of decomposition might easily have been shewn to where the whole matter is changed to a greyish colour, and chips off into fragments like pieces of a small bomb-shell,

shell, or to where the whole mass is nothing but a soft easily workable clay, shewing however still the curved lamellar structure, and what it once must have been.

No. 8 has an aspect much resembling basalt properly so called, but its fracture is flat and sluggish.

A cellular, or honey-comb mass, will often occur intermixed with any of the foregoing,—the cells of which are externally empty, and internally filled with powdery whitish oxide of iron, which immediately falls out when the stone is fractured, such is No. 9.

No. 10 is wacken, with much olivine interspersed.

And No. 11 has something of green earth, and something of olivine in specks and splashes.

No. 12 has rather more of a blueish grey than a black caste, probably from the felspar rather exceeding its usual proportions.

It is much to be wished that the term basalt could be extended so as to include all those rocks named wackens for although there is some slight diversity of fracture and frangibility, and some little variation in colour, yet a difference in name seems quite uncalled for in regard to them and only calculated to mislead.—However thus much may be said, that those rocks in this list named basalt, are strictly compact,—no casual mineral will be found imbedded,—whereas the wackens on the other hand, whilst they are sufficiently compact to exclude any other term than compact, are seldom quite entirely so. An accidental mineral of the kinds incident to amygdaloids, may almost always be detected in them, and this too,

too, together with the similarity of paste, serves to connect them with these amygdaloidal varieties, which, as elsewhere, in trap formations, here most commonly occupy the lower positions.

No. 13 is an amygdaloid which has been thought to resemble the toadstone of *England*. It has a black homogeneous paste containing chalcedonies, calcareous spar, and green earth. The former are often geodes coated externally with calcareous spar, and internally lined with minute crystals of quartz with calcareous spar filling up the cavity. Where green earth occurs in the same cell with siliceous crystals, the latter appear in a decaying state. The size of these imbedded portions do not, in general, exceed a nutmeg, although the chalcedonic geodes, &c. are sometimes a little elongated to the extent of three or four inches, and their sides are compressed.

No. 14 has the same paste as the former, though softer, and excepting green earth, has the same imbedded minerals; and when these are of a moderate and usual size, very pretty specimens of the whole rock are afforded, but in general this variety of amygdaloid envelopes very large sized portions;—a cylindrical geode of amethystine quartz was found measuring thirteen inches in length by two and a half inches in diameter. It was coated internally with beautiful quartz crystals, with calcareous spar, as stated in the previous specimen, filling up the cavity, and this mineral also coated the geode externally, and was seen much in splashes in the paste proximate to the cell. As regards these amygdaloids, it would seem in proportion as the contained mineral is large, so is the containing matter soft and friable, though still retaining its colour, a black, when fresh fractured.

No. 15.—Paste as before enveloping green earth, chalcedonies, and zeolites, the latter predominating.

No. 16.—Has a paste of a blueish grey colour, and appears almost completely saturated with calcareous spar; though much softer than any of those previously mentioned, it possesses greater induration than Nos. 17 and 18.

No. 19.—Is an amygdaloidal mass, consisting of innumerable pea-form nodules of calcareous spar, cemented together by a thin cement of basaltic or wacke clay of a light colour.

No. 20.—Is fully engrossed by minute crystals of zeolite, excluding from the paste any other mineral.

No other trap rocks, than those I have mentioned, are here of obvious and constant occurrence, at least if any other varieties exist I saw them not.—With regard to the simple minerals contained, calcareous spar is the most abundant, green earth, chalcedony, and quartz, are also very prevalent, but the zeolite minerals may be quoted as scarce. Well defined jasper is rarely seen, but something above an indulated clay, what may be termed semi-formed jasper, is of constant occurrence, so is hornstone; and both these last are to be found independant, but they are more generally lying contiguous to the limestone from which they are derived. The iron clay so easy to be met with every where, would hardly ever satisfy the mineralogist, for it is for the most part amygdaloidal, and not a simple mineral. It sometimes rises to the rank of a poor earthy red ore, and it is as such worked near *Barseah*, near *Raisen*, and at the source of the *Dasaon*, &c. Olivine throughout is every common,—but I have never procured either a crystal of hornblende or of augite.

But to the trap, not to the sandstone, belongs a hard white earthy limestone, harsh and gritty to the feel on the fresh fracture, and in which,
rather

rather sparingly, are imbedded small rounded particles of calcareous spar of a yellow colour. It belongs to the trap, and it is, moreover, ever attendant upon it throughout its range. Near the surface, or where it is in immediate conjunction with other matter, it may be found varying in colour and varying in the quantity of spathose matter. Very frequently, it will be of an ash colour, and the spathose particles, which are white and thickly set, forms the majority of the mass. Other specimens are reddish, brick red, deep chocolate, or brownish black;—others again might be produced, of which it would be difficult to say whether they were limestones or amygdaloids;—but always in proportion as it is coloured so is it the more clayey, gritty and impure,—more affected by foreign matter than that substance, which I have described, as the principal and characteristic rock.

This limestone rock is never found in the valleys, it is confined to the hills, and low swells, and generally forms the basement stratum in them, ascending somewhat above the level of the contiguous valleys. A stratum of this kind, is always sufficiently obvious in a hill possessing it; for along its sides, or at the ends, either a white patch mouldering by the weather immediately catches the eye,—or large rolled and angular pieces stand about, of a greyish colour, and very discernible from the blacker trap; though the continual line of the stratum, where it juts out to day, is not easily to be distinguished, the knobs, and exposed parts being generally covered with a blackish crust, and also intermixed with masses of indurated trap, and other more earthy matter, debris of the same, slid down from above. A white patch of this limestone, mouldering by the weather, is the source, from whence comes the particles of *kanker*, found intermixed with the black basaltic earth of the neighbouring valley, in such proportion, as to add increased fertility to it; and if a rivulet meanders through that valley, and such is generally the fact, patches made up of

of

of aggregated particles of the same, will here and there be found, and this it is which the native families pick out and work into lime. Where the grey coloured, large, rolled, and angular masses occur, there it is that a hornstone and jasper is to be found, though not both together in the same spot. The introduction of silica is of course the cause of the wholeness, and induration of those masses, which easily effervesce, but endless gradations are to be seen between these, and the two other minerals just named. If indurated clay, and semi-formed jasper are the derivations, the colour of these will, for the most part, be deep yellow; if green earth is the constituent of a neighbouring amygdaloid, the specimens will offer two colours, green and yellow, or yellow freckled with green. The hornstone varies much, from deep chocolate to straw yellow, from flesh coloured to nearly white. The flesh coloured hornstone, or chert, and the specimens shewing the lime-stone passing into this flesh coloured hornstone, or chert, found at *Bapyle*, about seven miles westward of *Ságar*, resemble exactly the same substances brought from the lias of the *Hattah* district, or eastward of *Ságar*; and this, together with the yellow fragments of lime-stone, of a tooth-like form, and somewhat dendritic aspect, also found at *Bapyle*, as well as elsewhere, is the fact that has much tended to increase the idea that the lime-stone of the trap of *Ságar*, and districts adjacent, is the lower lias half calcined, and disguised by the trap.

Some specimens of that which I have called the characteristic lime-stone will not effervesce at all, whilst others do so, but very weakly; but still oftener the acids take effect with sufficient briskness. Often the stratum of lime-stone is broader than the trap, which reposes upon it, and upon the mounds, and swells of lime-stone at the foot of the hills, occasionally will be found, a spot solely occupied by innumerable small fragments of spathose matter. These fragments are of a striated and radiated structure, and appear as if they had been purposely broken by the hand,

hand, and clustered together to the exclusion of any other matter ; however, it must be added, that some specimens of this species of *spath* are seldom wanting wherever the lime-stone rises to day, indeed the crystallized matter of this formation, when not imbedded in other substances, seems mostly to present itself with either a fibrous, striated, or radiated structure, and it is in its nature not pure and translucent.

A calcareous cement in these trap vallies, and near a streamlet, is often found forming trap tuff, that is, found uniting small *pisi-form* specimens of all the rocks, incident to this tract, into a mass, or bed of sometimes considerable induration, the surface of which will attract the eye by its rusty iron brown aspect, and its sterility.

It remains for me to describe the sand-stone underlying the trap, and so very often rising up through it, in the shape of hills, and swells. It is in no instance, that I have seen, interstratified with any other rock. Red marl, or clay, is sometimes to be seen alternating with it, in thin streaks, resembling the same rock under the *lias* of *Hutta*, &c. Galls of clay, or lithomarge, may frequently be found imbedded ; and as to its colors what elsewhere has been said of the same rocks in this regard occurs here, namely, they vary from a dark chesnut or chocolate, through red, reddish and salmon coloured, to nearly white and white. Massive kinds often shew two colors,—seldom more than two, and these two colors are a greyish white, and a deep chocolate, or it is a deep chocolate speckled with white spots. The slaty varieties, on the other hand, are exhibited clouded, streaked transverse to the structure, zoned, green, brown, red, ochre yellow, orange yellow, &c. &c., are, in fact, seldom exhibited, otherwise than with much diversity of shade and color, except perhaps a green variety. These slaty kinds are extremely micaceous, and the colors in the streaked varieties above alluded to, change at the line of cleavage ; and

lastly, the eye never perceives any inclination worth mentioning, or variation from the horizontal position, either where viewed in the whole alluding to their general air and look, or when viewed in any part as regards the constituent, angular and tabular masses of these sand-stone rocks. All this leads to the decision, that the rock in question is the new red sand-stone, and the lower division of that formation as defined by MACCULLOCK, otherwise the principal compact rock is by no means so tender as to be unfit for economical purposes. On the contrary, it is a hard, glassy, splintery substance, evidently composed of fine grains of sand held together by a solution of silica, and assuredly not a free working stone, though it is squarred with some difficulty, and failure, into appropriate masses, and every where used as the common building material. Varieties of less frequent occurrence, and differing little from the principal rock, except in being somewhat softer, are hewn for the architectural purposes of the small temples of worship, and chisselled to produce alto relievo representations of the various Deities, &c.

The trap mantles round at the feet of all these sand-stone hills, and renders them isolated as far as regards the surface of the land. The angular masses composing the hills, differ much in measurement, whilst they are set together very closely in a horizontal position; or if any remarkable interval exists between the masses, where the vertical separation occurs, it is generally empty, no clay, no debris, nothing will be found. The massive bi-coloured blocks are not confined to any particular spots, they are casual every where; and the same is to be said of the slaty species, for a nest of this latter will now and then be seen with an immense mass of the common characteristic massive kind resting upon it; though at *Maswási*, *Satgerh*, *Garspur*, *Bilsa*, and *Narsinhgher*, there would appear to be a continued stratum, occupying a place in the whole line of the hill, at each of these places. Often at the ends of the hills, there is a bluff
ragged

ragged perpendicular escarpment, and of course the rock is exposed from the base to the summit. Oftener there is a very easy slope, both at the ends and along the sides from the edge of the trap, that is the base of the hill, to within twenty or thirty feet of the top;—from this the rock continues upwards precipitous and rugged, and the crest is gained only after difficulty and search for particular points. The matter that gives the slopes described, is merely and exclusively the debris of the parent rock; and the vegetation, which clothes the surface, springs up between the fragments, time and the elements having worn off matter from those fragments, and so generated something of a soil beneath them.

I might have mentioned before that the principal quartzose sandstone, that which I have described, when first fractured, and brought from the quarry, is of a beautiful sky blue, which soon by exposure turns to such as the specimens shew it, a salmon color or flesh color, or slight modifications of these. The slates of *Satgerh*, if they split off less than two inches and a half thick, are too friable and are thrown aside as waste. Some of the quarries are already abandoned, and the whole appear to have been commenced about half way up the hill, on the crest of the more sloping part, at the eastern end, and thence along both sides to some distance. A slow fire of stout sticks of green-wood, is placed on the inner side of the table worked, which at length cracks it down about a foot, and as a whole, it is then tapped into parts of the required length and breadth for paving, eaves of houses, &c. It is the slates of *Maswási* that answer for roofing, these are generally something better than half an inch thick, and they are flexible, that is to say, the effects of the sun warp them, so much so, that if put on with a cement, they crack and break. Finally I may add, that a thin covering of refuse and stoney stuff, crowns the summit, resting upon table-shaped pieces, which repose on larger cubic masses, and thus far downwards the aspect of the whole is bare, rugged, and either perpendicular,

perpendicular, or overhanging at the sides and ends of the hill. To the cubic masses succeed a stratum of slate, after which again the massive in large blocks; both these covered by the debris, which I have spoken of, as forming an easy slope to the sides and ends of the hills, easy as to the length, but of troublesome ascent, because of the looseness of the component material. Such is the hill of *Satgerh*, surrounded on all sides by the trap, and such too is the predicament of every sand-stone hill, throughout this trap formation, with exception to a continuous stratum of slate, which of course is comparatively of infrequent occurrence, though small nests, or patches of it will always be found in almost every sand-stone hill exhibited through the trap.

A conglomerate or breccia, having an argillo calcareous paste, coloured red by the oxide of iron, and enveloping angular pieces of various sizes of the proximate rock, will often be found at the feet of these isolated sand-stone hills if a streamlet winds its course near; or there will be at such points, pudding-stones, and breccias, varying in color and aspect from this described, and occasionally too in having an argillo siliceous instead of a calcareous paste; but neither these nor that just described, are of any geological importance whatever, and the same may be said of the trap tuff.

Whether a well be sunk in the trap, or the sand-stone, the water is always found at a very easy distance. It may often be come upon, even during the dry season, within three feet of the surface in the vallies; sometimes it will be so low as twenty-five feet, whilst the medium is about twelve, and from that to fifteen. It is the toad-stone that limits the depth if the well be excavated in the trap;—the sand-stone is of itself sufficiently consolidated and retentive if the shaft has been sunk in it. If the edge of a hill or swell is pierced, of course the vertical height of such swell or hill

hill must be added to the measurement just given, for instance the well on the edge of the hill at the mint of *Ságar*.

The surface of the slope, where this well was opened, was thickly strewn with large black wacken boulders, and these continued for some little depth below the surface, enveloped in a dark reddish rusty ferruginous wacke clay, succeeded by a bed, ten or twelve feet thick, of large angular pieces of a deep chocolate coloured basaltic hornstone, underlied by a bed of yellow clay, which yellow clay or lithomarge formed indeed, a sort of coating or lacing to the superincumbent hornstone. To these followed a stratum of limestone, similar to that of the cantonment wells of *Ságar* resting upon the softer amygdaloids, which I have numbered: In these amygdaloids the water presented itself at a distance of forty-seven feet from the surface.

The following are the strata met with in a well in the cantonment of *Ságar* on a swell of trap.

	F.	In.
Rubbish and soil,	1	6
Indurated wacken in angular pieces of uniform arrangement,	10	6
Wacke changed by calcination into a species of puzzalana,	1	0
A thin black streak (rather remarkable) a vegetable deposit, changed by calcination, so as to disintegrate and fall to pieces in water,	0	3½
A white, hard, earthy limestone, sometimes effervescing weakly with acids, sometimes not at all; small yellow specks of calcareous spar are seen in it, and occasionally a concretion of a purplish grey colour occurs, violently affected by dilute muriatic acid,	23	0

	F. In.
Wacken with fibrous carbonate of lime and ditto in veins with calcedony,	7 0
An amygdaloidal wacken similar to the toadstone of England,	6 0
Total to the water,	49 3½

The difference in depth that occurs in the vallies, before the water is attained, arises from the form of the vallies being always concave, and the basaltic black mould deepest in the central parts. The soil, whatever is its occurring thickness, must be pierced, and also the indurated wacken or basalt, which ever it may be, and then the water is found resting on wacke' clay or amygdaloid.—The sand-stone keeps up the water even to a higher level than the amygdaloids of the vallies;—and the occurrence of either of these rocks forms all the phenomena of water in these districts.

Proceeding from the centre of the cantonments of *Ságar*, and travelling westward, you descend and cross the flat, which is the general parading ground, and at its confines, you come to a small isolated rise of sand-stone on your right, on which is built a *búrah* godown and a bungalow, and on the left a ridge, a branch from the sand-stone forming the basin of the *Ságar* lake; passing the town, and a little beyond the wall on the western side, a rivulet is crossed; then the road leads by a gentle ascent for two miles, to a low swell of trap, through a gorge or opening in which you enter the valley of *Bapyle*, and find a trap range close on your left, and one of sand-stone on your right, five or six hundred yards removed, forming the southern and northern sides of the valley. This valley is the practice ground of the Artillery, and must be at least three miles in length. At the western extremity another range of sand-stone occurs, either end of which

which range is within view, though it is elongated N. and S. to some little extent. A high rugged romantic hummock, capped, in a picturesque manner, with a disproportioned mass resembling a rocking-stone, is joined by a low neck to the main sand-stone range here, and partly on the declivity of the main sand-stone, and partly on the low neck is situated the village of *Bapyle*; opposite the hummock, only separated by a little broader space than is occupied by the intervening road, the trap range, the southern boundary of the valley, comes to a point, where is seen the lime-stone, and the flesh coloured cherty matter, forming a belt round the base of the hill, and lying about in large whitish and greyish masses.—The trap range does not expire at this point, it merely, instead of continuing as it had done heretofore in an east and west direction, turns suddenly to the south, and sweeping round to the west again, forms by so doing another large valley, along the northern side of which you proceed on the route after leaving *Bapyle*. The river *Dāyon* is crossed at *Sekorah*, thirteen miles from *Ságar*, and then *Gámharáah*, another village occurs, the whole way being on the trap, and the road at a little distance from the trap and sand-stone hills, until at length you gradually ascend the sand-stone hill of *Ratgher*, twenty six miles from *Ságar*.—This hill is wedge-shaped, lengthened out east and west, and at the west end the fort is placed on the brink of a high perpendicular cliff, at the base of which cliff flows the *Bína* towards the north. To cross the *Bína* you descend the ridge of sand-stone before you reach the fort, turn out of the village down to the right, or northwards into the low ground. The ford of the stream is filled with large masses of sand-stone, and is to the traveller, particularly at night, very troublesome to pass.—After gaining the west bank fourteen miles over an undulating tract, having a gentle ascent, brings you to *Bagrode*, where commences a trap range on the crest of which you proceed to within three miles of *Garspur*. During this course, you see to your right a very extensive plain, studded over with trap, and

sand-stone

sand-stone hills of various forms and aspects, and among these the remarkable sand-stone hill of *Teonda*, with its summit presenting the appearance of a hill fort wall, with its buildings within. The route by *Teonda* from *Ratghar* to *Bilsa* is often taken for wheel carriages, to avoid the pass of *Garspur*. This pass, the summit of which is about three miles from *Garspur*, occurs in consequence of the road descending the southern side of the chain, the crest of which it had hitherto occupied in an east and west direction. The chain too here becomes forked, one limb stretching south west in a straight line, though not with perfect continuity of existence, to near *Raisen*, the other proceeding directly west to the *Betwa*. In the angle thus formed the road descends diagonally, and is extremely rough. It is covered, from the highest part to the lowest, with large globular and angular masses of compact and amygdaloidal indurated wacken, of a black colour, whilst the enveloping clays, in some parts of the line of descent, appear yellow, in others a dirty reddish brown; and there likewise occur at least two strata of the characteristic hard white lime-stone, the one rather above the centre, the other near the bottom. At the bottom or base of the hill there are collected innumerable masses of the same black boulders as belong to the hill, intermixed with pieces of black horn-stone shewing veins of white quartz; also knobs of indurated clay, or semi-formed jasper of a yellow color, or yellow and green two colors; botryoidal and mammillated lumps of a yellow horn-like chalcedony decaying, and variegated by the green earth contained; geodes of a pseudo amethystine quartz, often filled completely with confused crystallizations of the same, intermixed with balls of either a yellow, or pure and transparent calcspar; thin tables of quartz; small flattened pieces of common chalcedony;—thin tables of quartz, white and opaque alternating in layers with chalcedony greenish grey and translucent, and coated externally, on the flattened sides with crystals of quartz small and brilliant, and other similar siliceous and calcareous matter, (the latter not separate

and

and alone;) such as once probably was more intimately connected with the amygdaloids, and which now for ages have in the main resisted the force of time and exposure. The moment you are clear of this fallen matter at the foot of the pass, you step on the sand-stone, which is exposed to-day in the whole axillary part, the bounding trap ranges resting upon it. It is uneven, much covered with fragments; swells and hillocks appear upon it, and amongst these that on which is placed the village of *Garspur*, higher than the rest somewhat, but not so high as the contiguous trap. It is situated about a mile and a half from the foot of the pass, and it possesses some little length, or at its foot the road runs about half a mile, in a W. S. W. direction. After leaving the red ground, and coming on the black soil again, the sand-stone still continues to attract occasional attention, protuding up through the trap, until you have passed the distance of four miles. From this point, for twenty miles, there is a general inclination of the trap land to the *Betwa*, the hills being farther, and farther removed from the view, as you advance in the large open cultivated plain, at the W. S. W. extremity of which stands *Bhilsa* on the east bank of the *Betwa*. Here the sand-stone occurs as a large plat of some hundred yards diameter, generally even with the trap; but in the central part, it suddenly rises up, and forms a curious clump about one hundred and twenty feet high and flat at the top, where there is just sufficient area for a Moslim tomb, and another small building or two, remarkable in the distance from their white appearance. If *Bhilsa* be taken as a point, and a radius of six miles swept about the west bank of the *Betwa*, it would every where pass over sand-stone hills; they are much clustered thereabouts. *Khanakerah* where is seen a very anciently sculptured rock is situated amongst them. The town of *Bhilsa* is placed on the east bank of the *Betwa*, between it and the solitary sand-stone rise alluded to. In a N. W. direction a bed of iron clay slopes off this rise, so that the *Betwa* and the *Bheis*, which joins the *Betwa* a little northward, cuts through it, and the

angle, formed by the junction of the rivers, is occupied by it ; but, after having gained the west bank of the *Bheis*, it is soon lost. The road now continues on the trap, the hills for six miles being solely of sand-stone ; more west than this it is merely a trap plain on which occurs *Kamkera*, twelve miles from *Bhilsa*. Beyond *Kamkera*, the route being now to the northward of west, the plain still continues for five miles, and then you ascend and cross a range of globular trap hills, distant from *Barsia* ten miles, with nothing remarkable in the interval. *Barsia* is on a large mound of amygdaloidal iron clay, sterile and bare in some parts, apparently highly productive in others ; in the immediate vicinity of the town it is gravelly and red in aspect. Four miles in advance, or at *Ránagerhi*, this clay again presents itself, rises even to the rank of an ore, and is as such worked, and the produce sold sufficient for the purposes of the bazar of *Barsia*. Immediately around *Danaora* the sand-stone hills shoot up. *Kalukera*, sixteen miles from *Barsia*, is on the trap ; the *Sumera*, a small stream, winds about the village, washing out its way through large blocks of wacken and basalt. The fort is built of egg-shaped masses of the latter, truncated at one end, which end is set outwards, something like the flint with chalk to be seen in some of the ancient houses of Hampshire, such as Chawton-house and Farleigh Wallop, though the stones here used are four times as large as a common flint. Between *Kalukera* and *Narsinhgerh* (a march of fourteen miles) you pass the *Parwa* and *Párbati*, only worthy of notice as shewing in their beds the trap and basalt covered with a whitish coating, and cracked in to various prismatic shapes. The sand-stone range at *Narsinhgerh* runs directly N. and S. beyond the reach of sight. The village is situated in the deepest part of a circular hollow formed by the partial winding of the hills, and the trap has there found its way, though a basement of sand-stone completely occupies the narrow throat or entrance over which the road leads into the hollow. The trap is composed of balls decomposing

decomposing of the concentric lamellar kind, and the water in a well, where this trap was identified, was fifteen feet from the surface in the month of June. Rising out of this hollow you go up a very long and steep ascent of sand-stone, and when the crest of the hill is gained, there is but a trifling comparative descent on the west side to reach the trap. The space between this and *Bhopalpur* has nothing of interest, the country is more undulating, and more open, hills and hillocks are less seen. The *Kassa* and *Dúda* rivers, occurring before you reach *Bhilsa*, differ nothing from the *Parwa* and *Párbati*, neither does the *Nawas* in advance at *Bhopalpur*. It is fifteen miles from *Narsinhgerh* to *Bhilsa*, and ten more brings you to *Bhopalpur* on the banks of the *Nawas*, and to an extensive bed of basalt (the Rowley Rag,) not rising above the surface; thirty-six miles beyond this point in the direction of *Patan* and *Kota*, i. e. at *Bhalta* the trap formation ceases. It is seventy-two miles from *Ságar* to *Bhilsa*, and eighty-two from *Bhilsa* to *Bhopalpur*. In the first part the vallies and low lands are generally pretty well cleared and cultivated;—in the latter they are wild and their fertility neglected; they are overgrown with brush-wood and jungle, and cultivation, at least along the line of march, is only seen in small patches about the villages, just sufficient for the support of the inhabitants.

Departing from *Bhilsa* and taking the route to *Hasanábád*, the sand-stone hill of *Raisen* is met with at the distance of fifteen miles. It is in shape like that of *Ráitgerh*, but the highest point is the east end, and the fort is perched upon it facing that quarter. It is very conspicuous for many miles around, and said to have been built by the celebrated King of *Ayodhyá*, as a place of refuge from the temporary anger of his brother, and that the hill arose at his desire, but whether with the aid of an igneous or aqueous power the upheaving was accomplished is of course the question here requisite. *Banchor* the next stage, as its name imports,

is the entrance to a dense forest of timber trees, crowning the summits, and sides of a very long winding sand-stone range, upon which the road passes through *Chiklod*, *Kullagerhi*, and *Akalpur*, or a distance of twenty-four miles, and in a westerly direction, and then turns south or down the slope of the hills twenty miles, through *Nezer Ganj* and *Chouka* to the alluvium of the *Nermada*. The road descending is extremely rugged, and occasionally slippery from the size and position of the slabs, it is in fact nothing more than a water course: It is sixty-eight miles from *Bhilsa* to *Hasanábád*. The edge of the alluvium is three miles from the *Nermada*. The sand-stone peeps to day at *Hasanábád*, and is seen no more. Fifteen miles over the black basaltic mould or alluvium brings you to *Petraota*, where commence primordial rocks, ending in the granite of *Nimpáni*, *Shahpur*, and *Beitúl*.*

I ought to have stated, that the trap range branching off at *Garspur*, approaches very near to *Raisén*, and at *Banchor* forms the eastern boundary of the small valley there; and then after bending about, in a southerly direction, and skirting the sandstone, it proceeds eastwards by the source of the *Desaon*, *Sírmao*, &c., forms, in fact, the southern boundary of the trap formation as described.

Northwest of *Ságar*, or in the direction of *Seronj*, and north, or in the direction of *Maltoun*, still the country is precisely the same, except in the latter case, the sand-stone hills predominate. Eastward of *Ságar* the trap is at *Sanowda*,—so is it at *Shahpur*, or a march beyond, and ceases only near the nameless rivulet between that place and *Pathariáh*.

North-east

* Between *Kaisler* and the *Bhora Nadi* there is coal. The *Towa Nadi* should be followed to its source, or until it is shewn from whence it receives the coal fragments found in its bed.

North-east of *Ságar* the sand-stone often appears, but only as swells rising little above the general level. The trap prevails until you have passed *Sanwa*, three miles and a half, there it ceases entirely, distant from *Ságar* forty-five miles. From *Sanwa* east to *Sátpára* and *Panchamnagar* in the lias, it is not more than nine or ten miles, and these places are about the same distance from *Hírapur*, due north of them. A section made from *Hírapur* to either of these places, and from them to *Sanwa*, would be highly interesting, and most probably establish clearly the relations of the granite, conglomerate, new red with its overlaying trap, and the lower lias.

Where the trap ceases, it does so abruptly. It possesses a vertical thickness of about sixty feet, and it has been cut down to make the slope easy for the road. At the foot of this short pass, which is still very steep, is the sand-stone supporting the trap; and this sand-stone is not now a hard, glassy, difficultly frangible, splintery substance; it is become a fine grained, white, saccharine mineral, with a flat even fracture, coloured externally a light red; and with the exception of one fall, about half a mile after leaving the trap land, it presents a very even surface, its blocks being freed of debris forming a pavement base for the road, a distance of four miles; the sides of the road meanwhile, shewing much overlying loose matter with long grass intermixed, and occasionally trees, as you advance, approaching more and more to something of a timber size. Only one small hamlet presents itself distant from the road side on the right hand, perhaps a mile. At the expiration of this wild flat, three hills are crossed in succession, composed of the sand-stone masses, rather sparingly and loosely set together in much red clay, and quartzose matter, and covered very densely with jungle and forest wood. These hills are of no great height, but being separated one from the other by ravines or water-courses, they are short, steep, and troublesome at the points of separation. From

the verge of the summit of the last hill, which summit is more than a mile in breadth, you look down, over an intervening conglomerate range, into the valley of *Hirapur*;—and on descending from the summit, within one hundred yards from the base, speaking as to the line of road or slope, not to the vertical height, you see the new red sand-stone reposing, in a horizontal position, on a stratum of brownish black ferruginous clay, and earthy iron ore of the same colour.—Was not the sand-stone to be seen actually reposing on the stratum just mentioned, still that a change had taken place no one could fail to observe; for the ground, from being bright brick red, suddenly changes to a brownish black, with a harsh gritty gravelly tread, as if you were in the neighbourhood of some great foundery; and so it continues to the base of the hill, and onwards along the low ground as far as the conglomerate hills. These conglomerate hills surround the whole valley of *Hirapur*, and are heaped up immediately on the granite from whence they are derived, or else they rest on horn-stone petrosilex. The individual hill at the south-west point, or the point at which the road enters the valley, is not more than two hundred yards removed from the base of the sand-stone hill,—only separated by a small hollow or curvature, strewed over with lumps of iron ore and pieces of quartz and felspar, &c., but not a fragment of the new red. The component matter of this conglomerate hill, as well as all the rest around the valley, is a sombre, dark red coloured clay, enveloping variously formed large masses, the conglomerate, or Breccia proper, made up of angular pieces of white felspar, and occasionally grey pseudo limpid quartz, seldom less than an inch in size, agglutinated by a highly indurated cement of the same sombre ferruginous clay just noticed; or the paste is still harder, common quartz discoloured by the oxide of iron. From the conglomerate boundaries to the centre of the valley, the granite every where is open to-day and laid bare; it rises also in the centre, sinking towards the bounding hills, and iron ore is strewed about all over those hills, and at their feet,

feet, even on the granite. The form of the *Hirapur* valley is oval; its longest diameter is from west to east, and it is in that direction about a mile; from south to north it is not more than a quarter of that distance. About the centre, or perhaps a little to the westward of it, is a large pond, on the north bank of which is the village, and near it, or on the east side, a small square *Gerhi* or *Fortlet*. On two mounds of granite near the *Gerhi*, also on a swell of the same on the south edge of the pond, nowhere else, masses of gneiss, some half dozen in number, are sticking up, which, from their slab form and slight inclination, oddly and much resemble old tomb-stones in a church-yard. Both the gneiss and the granite if they have any inclination dip to the S. W., but of the conglomerate, it being a heap of clay and large stones, nothing very satisfactory can be said; here and there, amongst the rounded and angular masses, one or two larger than the rest, would seem to stand up, conforming in position to the gneiss, with their broader sides something sloping to the same quarter as the granite, and the gneiss, viz. to the S. W. This sketch brings the trap and sand-stone to their N. Eastern limits.

At *Hirapur* is seen the granite, capped by heaps of ferruginous conglomerate, which conglomerate is connected with a stratum of iron ore, on which the new red sand-stone is seen to repose:—All this within the space of a few hundred yards. The new red sand-stone, from this point, continues, in the direction of *Ságar* bare, and exposed, freed from any overlying rock, a distance of six miles, or to where it is met by the trap, when for forty-five miles the two together progressively increase in height, until at *Ságar* they have attained their greatest elevation, or are at least one thousand feet higher than the spot, where the just noticed connection commenced. If a line be prolonged from *Hirapur* through *Bhilsa* to *Hasanábád*, or that quarter of the compass towards which the primordial rocks at *Hirapur* would seem to dip, such line will have in it almost all the

the principal points, where the sand-stone protrusions are entitled to the rank of hills, and where they are more elongated individually, and more clustered together; for instance, *Dhamúná*, and *Maltoun*, *Gherpára*, and *Sátgerh*,—*Bapyle*, *Rátgerh*,—*Gráspur* and *Bhilsa*.—The eastern edge of the sketch, as stated in the commencement of this notice, is where the thin covering of the lower lias lies on the upper portion of the new red rock series, viz. clays, marls and calcareo arenaceous sand-stones, tender and often variegated, and it is desirable to note in particular that such is the case. At the descent to *Tendukaira*, or at the S. E. corner of the trap, it is a sand-stone rock; but the connection of this rock, with the subjacent matter along the south boundary, is concealed by the basaltic alluvium of the *Nermadá* interposing. The western limits join the trap of *Malwa*, and therefore it need only be added, that I bring the sand-stone as far west as *Nursinhgerh*. Along the north side probably there is sand-stone the whole length, it certainly does reach up to *Maltoun*, and forms the bounding rock thence to *Hírapur*; and iron ore occurs at many points in that line similar to what it is at that particular spot.

To conclude:—The rock about *Sehore* and *Bhopal* is, upon good authority, considered as similar to that of *Ságar*; although there was information given, that rock salt was there produced, and of course the mind conceives *Gypsum*, &c. as equally existing, or in a word, that the superior portion of the red marl formation was to be found west of the somewhat diagonal line pointed out; but the accuracy of this last report is at present to be doubted, more particularly, as *Gypsum* is only known in the *Ságar* bazar as a production of *Rájputána*, and the salt chiefly used is that of the *Sambher* lake, annually brought along these latitudes, and sold by the *Binjaris* as far east as *Sergúja*. However be this fact, it is, with the exception now noticed, that I wish to offer the sand-stone of the districts described, from a general personal acquaintance with the whole, as
remarkable

remarkable for the great extent of range it possesses, for the unique abstracted nature of the thing itself, and mode of occurrence :—It is ever the same thing at every point of view, void of clays and marls, or any other interstratification, it is the same identical mineral, protruding itself through the trap, (where the trap overlies,) in large angular masses set together horizontally without cement ;—a substance of apparent simplicity of composition, fine grained, hard, vitrified and brittle where it is localized in the midst of the trap of supposed igneous origin, and a free stone of flat even fracture beyond those localities. Highly micaceous and variegated sand-stone slates occur in it in nests, or as continuous strata. The massive rock is itself also often bi-coloured, rarely many coloured. It might be explained and named as the middle division of its formation, but it is not seen to rest on a conglomerate of its own, on the contrary, it is itself seen, at *Hirapur*, to rest immediately on a conglomerate incident to the granite rock there occurring.

The lime-stone of the trap is a hard white earthy substance, enveloping a few small particles of a yellow calcareous spar. It occurs constantly as a component part of the hills and swells,—not of the lower grounds, unless as detritus, in small particles washed down from the hills, when it intermingles with the black mould, and then that soil becomes, from the intermixture, remarkable for its fertility. It deserves attention particularly for the semi-calcination, and sometimes more, which it would seem to have undergone, and generally for its defiance of classification, and for the jumble, and apparent dislodgement from original position, which it now exhibits heaped up in the trap :—And, if with these considerations, it be reflected that there is no oolite, no chalk, nothing in a word posterior to lias, the hope may be indulged, that the chert and calcareous dendritic fragments, occasionally found will, together with other to be substantiated facts, eventually establish it as a continuous portion of the neighbouring lias,

lias, disguised, and displaced when the trap was erupted, or by that explosive power and plutonic heat, which glazed and hardened the sandstone rock.*

As to the trap it is here a very extensive deposit, though still but part of a whole. All its rocks are basalt, or matter of near alliance with it, and composed principally of hornblende and felspar in an earthy state. It is altogether an earthy deposit; varieties of green-stone, or basalt, or any rocks of a distinct crystalline texture are wholly wanting, and by such deficiency so many others of the trappean list are equally, it would seem, not to be found; and the idea obtrudes, whether the circumstance of a simple mineral, like this sand-stone described, being the including rock, or basin, has not debarred complexity, and preserved to the trap singleness of feature and texture, and manner of being. The color of the harder basalt is either greyish black, or jet, and that of the softest kindred clay mottled greenish grey; and all other varieties, as to induration or complexition, vary between these extremes. In the hills, the indurated masses have mostly their angles rounded, and appear heaped up together with a variable proportion of wacke clay, added to which, there will be seen frequently, a patch or lime-stone stratum, occurring nearest the base. The base of the hills is invariably broader than the summit, and, if the sides of a hill are smooth and even, balled trap or basalt, often a concentric lamellar variety, will be the principal component matter, decomposing and decomposed into a predominating workable clay, still shewing the parallel converging layers. The smaller vallies appear much scooped, or
concave,

* The first noticing of the peculiarities of the lime-stone is due to Captain FRANKLIN, and the idea of the oolites and chalk is given nearly in his own words—but I am responsible for hazarding publicity.

concave, and underneath their black looking soil lies wacken or basalt, in form and size, about a cubic foot, disfigured, and often arranged in an uniform manner. The globular wacken and basalt partially supersede this arrangement in the low grounds, but neither basalt, nor wacken, with step-like uniformity, will ever be found forming a hill. Some one or other of the amygdaloids, particularly the toad-stone, succeed the soil, and compact trap rock in the vallies, and they are often observed occurring at the feet of the hills; but these latter, it should be remarked, are often merely this globular trap, distinctly thrown up on a sand-stone basement, or flat. *Narsinhgerh* remarkably shews the trap every where surrounded by sand-stone, and the lake of *Ságar*, on a larger scale, is a distinct basin of sand-stone with an inner coating of trap. Altogether it may familiarly be depicted as a dark superficies speckled with spots of red; the bird's-eye view also presents the thing as a net work scene, the interstices being formed by the numerous hills, and low chains of hills, winding about. No sudden brush of the ocean could have left such remains as are here seen, and, unless the occurrence of stilbite* be decisive, there are no facts to plead for the aqueous origin of the trap, except the all-pervading character of its occurrence, and its possessing an axis or general line of bearing; but neither of these, indeed, plead exclusively for it; whilst, on the other hand, common observation here forcibly incline the mind to recognize an opposite theory, and imagine the action of a globe of compression, or rather of a common mine:—The effort is made, and the entonnoir formed by the more verticle rays sending upwards the stuff, and strewing it in heaps all about; whilst those rays, that are more inclined, will either compress, and shake, or split, and penetrate according to the various natures of the materials

* It has been said that the occurrence of stilbite is decisive of the aqueous origin which is the reason why I mention stilbite being found.

materials of which the sides are composed ; applied to the trap, it will thus be an overlying rock, whether it be, as it is seen here, only on the surface, or whether it occurs, as it so often does elsewhere, and here too perhaps below the surface, interstratified, entangled, and in what not position in other rocks. The works of after ages, by means of either agent,—the ocean, for instance, acting through those ages, might have exercised denudation, and disturbance, until only a portion of a more horizontal ray is occasionally to be seen, indicating an explosion somewhere, either proximate, or remote from the spot:—a stratum,—a dyke or a vein occurs of no obvious connection. If the simile of a mine be at all admissible, it may be carried on and said, that compared with the solid contents of the globe, the product here seems to have been from a line of *Fougasses* continually working results through a long course of time ; the ruin lies about, a small portion of which is a half calcined lime-stone, can it once have been the *lias* ? and the chert of *Bapyle*, and the small fragments occasionally found of a yellow dendritic lime-stone, the only aids at present in corroborating the idea ? and the clays, the yellow and the deep chocolate, and the marly ochres, are they the more unchanged matter, and the laterite an iron ore disfigured and impoverished ? The cellular, or honey-comb lava-like variety of trap occasionally is met amidst the abundance of other kinds ; whilst the sand-stone rock is, as it remains, shook and split and vitrified, but not displaced or inclined:—The fluid matter seems to have shrunk and sunk, and thus, in a great measure, arises the phenomena of the trap in the low grounds, and the disrobed naked appearance of the sand-stone islets, as if their clothing had slipped down. But the incumbent waters by their under currents, not by violent agitation, would seem to have rounded the masses, and further confused the heaps thrown up, and after the igneous agency had ceased to act, every trace of the sphere of action would be by those waters quickly obliterated. The small hummocks, which occur so often, and more particularly at the ends

ends of the hills joined by a low neck to them, are mostly amorphous, and then composed of the harder materials ;—but often they are something of a cone or a truncated cone, and their component matter soft. They are here of no importance, having been for ages exposed to day they have become worn at length into that shape which best resists much further demolition, and so now remain.

It is almost superfluous to add that no fossile remains have been found by me.

The following is a summary of the foregoing sketch : The latitude of *Hirapur* is occupied by a primitive range, and so is the skirt of the alluvium south of the *Nermada* ; in the longitude of *Udayapur* will be a western limit, and a granite range, crossing the *Nermada* at *Jebelpur*, and stretching northerly, forms the eastern boundary. This basin elongated E. and W. formed of primitive rocks, has, in its interval or hollow, the sandstone deposit, in some one or other of its forms, exhibited nearly throughout ;—obscurely as when seen through the trap, or thinly covered with a coating of lias ; or openly as in the hundred and ten mile line from *Ságar* to *Jebelpur*. From *Udayapur*, or the western limits to the central part, *Ságar*, the trap rocks blacken the surface, and at *Ságar* they rest on the sandstone, which appears not to have much intermediate between it, and the proximate primitive rocks. It is a continuation, and a sort of north eastern bend of the rock of the *Malabar Coast* from *Baroda* as a point, and itself contains more, perhaps, than fifty-four thousand square miles.

IV.

R E M A R K S

ON THE

GEOLOGY OF THE COUNTRY

On the Route from Baroda to Udayapur, via Birpur and Salumbher.

By JAMES HARDIE, Esq.

Assistant Surgeon, M. A. S.

IN this communication I do not pretend to give a correct geological description of the country through which I have passed. This would be an undertaking of great difficulty and one which would require that our observations should be made on a much more extended scale, and with a far greater degree of minuteness than can possibly be done by a traveller, who is merely marching in a rapid manner from one point to another. Such remarks, however, as the following, if they be correct, may prove useful in as much as they afford an opportunity of comparing notes with the observations of other travellers, and thus we may eventually succeed in obtaining a pretty correct knowledge of the minuter Geology of India, the general features of which have been already described by one of your members.

From

From *Baroda* to *Birpur*, a town of considerable extent, situated about twelve miles N. W. of *Lunawara*, and distant from *Baroda* about seventy-six miles, the country affords little to interest the geological observer. Proceeding by the direct route via *Balasinur*, and till we reach the last mentioned town, a distance of nearly fifty-six miles, in a northerly direction, we perceive nothing but a uniform expanse of alluvial soil. We now, for the first time, observe rock formations and several gentle rising grounds give to the face of the country in the neighbourhood, a wavy outline. *Balasinur* is situated on one of these rising grounds, and the only rock which presents itself is a conglomerate, principally composed of agates and other quartzose minerals. Some of the agates were of considerable size. This rock is not stratified, and appears at the surface in the form of large lenticular masses. It is perhaps a similar formation to the cornelian rocks in the neighbourhood of *Barra*, but, as I have seen no good description of these, I can only state this as a mere conjecture.

Distant from *Balasinur* ten miles, still in a northerly direction, stands the small village of *Pandua*. In its neighbourhood are seen several small rounded hills or rising grounds presenting the bare rock at the surface. On examination I found that these were composed of different modifications of granite. The first was a very close grained grey granite composed of greyish felspar, translucent quartz, and dark colored mica with hornblende, occasionally disseminated through it. This passed into a coarser granite composed of large masses of reddish grey felspar, nearly transparent quartz, and silver colored mica. Both the mica and quartz occasionally appear crystallized, I could not procure a hand specimen in which this was distinctly shown. The one in my possession, and which shall be forwarded to the Society, is sufficiently characteristic in as far as regards the mica. Some of the masses of quartz in this granite were
upwards

upwards of a foot square, and many of them nearly transparent, through the substance of which prismatic crystals of schorl were seen to shoot. These rocks were not stratified.

Birpur is situated ten miles N. of *Pandua*. The route for the first five miles lies over the usual plain of *Guzerat*: we then enter a more hilly country; the hills, however, are very low and their summits are occupied by a table-land. *Birpur* stands on an elevated situation, and the low hills with which it is surrounded, are covered to a great depth, as may be seen by the ravines and nullah courses, by an alluvial soil similar to that of the plains. Owing to this circumstance I had no opportunity of examining the rocks in situ—the stone used in building, and from the quantity of it seen it must have occurred in great abundance in the neighbourhood, was a very compact quartzose sandstone, or rather a ferruginous quartz of a red color. From the appearance of the fragments it must occur distinctly stratified.

We had now left the rich and highly cultivated plains of *Guzerat*, and had crossed the barrier of a hilly and jungly portion of this district, not only the face of the country had changed, but the appearance and character of its inhabitants. Heretofore we had a rich alluvial soil, cultivated by a comparatively speaking civilized, or at least a more peaceable people—numerous thickly inhabited towns and villages were seen scattered over it—it is watered by numerous tanks, and wells, and rivers, and the country resembles more the richer portions of Bengal than any other part of India which I have seen. The surface of the country passed does certainly not present much to attract the notice of the Geologist; with the assistance of boring instruments, however, much valuable information would, no doubt, be obtained, and an interesting comparison might be drawn between the alluvial formation of this district—that of Bengal—the

London

London clay formation, and other similar formations both in Europe and Asia.

Whatever might have been the agency, or the succession of agencies, concerned in forming the alluvium of *Guzerat*, it is abundantly obvious that it could not have been gradually formed by the debris of the rocks in the mountainous portions of the district washed down by rivers, nullahs, &c. From this source a portion of it might, no doubt, be derived. By its extent, its depth, the high situation which this deposit frequently occupies; (as at *Birpur*, just mentioned) we may learn that it must have been the result of some more energetic cause.

The extent of the conglomerate formation at *Balasinur*, I had no opportunity of ascertaining, nor do I know its relative position with regard to other rocks—it probably, however, rests on the granite which underlies the alluvium—might not these conglomerates be cotemporaneous with the lower beds of the alluvial deposit, modified by some local cause, affording a cementing medium to the loose particle, connecting them together and thus forming a nucleus round which others would collect? This is a mere conjecture.

The hills at *Pandua*, were no doubt, formed by the outgoings of the underlying granite—a granite which appeared to me to belong to a very ancient variety—an older variety indeed than any which we shall have occasion to mention in the sequel of this paper. The crystalline nature of its component parts—the transparency of its quartz—the whole appearance of the rock, and the situation which it occupied, led me to draw this conclusion.

From *Birpur* our march lay through a hilly and jungly country to a small village called *Dewári*, six miles distant, in a N. East direction

x

from

from the last. The hills were ridge-shaped, and their summits presented in the distance a uniform and even line. Their slopes were covered with loose fragments of the wells composing them. The preponderating rock was quartz, distinctly stratified. On examining a hill in the neighbourhood of my camp, I found the following series of rocks arranged in strata, which were highly inclined and dipping towards the N. W. 1st, a rock of the nature of quartz rock, of a greyish color, and inclining to slaty structure—it seemed to be quartz rock passing into clay state—it was very hard however, and was principally composed of quartz. 2nd, a ferruginous quartz, of a reddish color; and 3rd, a pure white quartz. The last had nothing of a slaty structure, and, indeed, could not be said to be distinctly stratified. These three formed frequent alternations, the pure white quartz appearing in the shape of a series of unstratified beds interposed between the other strata.

Ten miles distant from the last, in the same direction, stands the village of *Panwára*. For the first four or five miles the country was covered with a thick jungle, and the line of march was enclosed by ridge-shaped hills which presented a bold and craggy outline—the rocks forming them were arranged in a highly inclined position, and consisted of different modification of quartz rock and clay slate which alternated with, and passed into each other. After having passed a narrow Ghat, which though steep, is not difficult, we entered an elevated plain, level and covered with a thick and apparently rich soil, in many situations well cultivated and over which are scattered numerous fine trees. From the top of the Ghat where the plain commences to *Panwára*, is a distant of about five miles.

In ascending from the plains of *Guzerat* to our present situation, we have come at once among rocks of the oldest class, and we have met with nothing like any of the newer varieties. We have passed the western
boundary

boundary of the great primitive district which forms a large portion of Central India, and which traverses from N. to S. the whole of the peninsula, being connected, indeed, at one point or another, with all the great primitive formations which exist in *Hindustan*. The rocks which as yet we have seen might be termed, perhaps by some, "transition." In the present instance I can see no use for this distinction. From the rocks which surround us to the more decidedly primitive ones we can trace a regular gradation. They pass into—and in many instances alternate with—each other. In short every consideration points them all out as belonging to one grand series of rock formation as the result of one general cause.

In the deposition of a formation so extensive, a long period of time would doubtless be consumed, and though the precise period of their deposition might be different in different instances—one being formed when the forming cause, whatever that might be, commenced to operate, and another when it was about to cease,—this, though it might modify the internal structure and appearance of the different rocks composing this formation would not justify us in including them under different classes.*

In the district of *Kutch*, towards the N. W. I believe, from specimens which I have seen, that a series of rocks of a newer formation than *lias*, and from that upwards, may be observed. I drew this conclusion from the very numerous fossil organic remains which many of these specimens exhibited. These remains were shells belonging to varieties which have been ascertained to be characteristic of the newer classes of rocks in other

* I am uncertain with regard to the nature of the rocks at *Birpur*. As I did not see these in situ, I cannot say decidedly in what class they ought to be included—they, perhaps, belong to a newer and overlying variety.

other countries. Nothing of this kind can be traced here, however, and from the paper of Captain J. STEWART, in the Bombay Literary Transactions, the same remark may be made regarding the boundary of this great formation on the route from *Baroda* to *Mhow*.

On leaving *Dawárí*, we proceeded on the usual direction over the level plain before mentioned, till we reached the *Bhítál* (i. e. a community of small villages) of *Hartúna*, which is situated eight miles distant from the former. We still found the surface of the plain covered with a thick soil. In some situation, however, small hills or rising grounds were observed which exhibited at their surface the outgoings of the inferior strata. These were as before quartz rock and clay slate, the latter was now much more abundant than formerly. Strata were still highly inclined and dipping as usual.

At this place (*Hartúna*) there was a great scarcity of water, and the *Gosáin* of the temple of *Náthdwára*, had sent some workmen to dig a well. They had penetrated about thirty feet through the rock in a low situation, and I had thus an opportunity, the first which had as yet offered itself, of examining the strata in the plain. I here discovered a distinct and separate formation from any which I had seen during this march in a series of overlying rocks. The first rock which presented itself, was a distinct sandstone, with a clayey basis, and of a soft friable nature. It was a variegated sandstone, with spots of a reddish color dispersed over a whitish ground. Below this was another variety of sandstone of a more compact nature than the last, and of a whitish grey color—it was a calcareous sandstone, effervescing with acids—the proportion of lime in it was, however, very small. These two were arranged in strata which were very slightly inclined.

These

There can be no doubt, but that these rocks belong to a newer class than any which we have yet seen—the extent of the formation I had no opportunity of ascertaining—it probably occupies, at least, all the lower portions of the elevated plain on which we were encamped, the rising grounds, as we have seen, being formed of the nearly vertical strata of the underlying rocks. Nothing like organic remains could be traced, though I examined with care the different masses which had been thrown out by the borers. Through the above rocks a vein of quartz was seen to pass—it gradually narrowed from below upwards till it terminated at the surface, where it was about a foot and a half in thickness, the lowest portion of it seen, being about two yards broad. The quartz was of a pure white color and crystallize texture. It was not stratified, but presented the appearance of a number of rounded masses closely cemented together—the *Huttonian* might say, that it derived this form from having been ejected from below, the *Wernerian*, perhaps, that it had been a previously existing rent in the strata which had been filled up from above by rounded masses of quartz derived from the neighbouring hills, and which are seen strewed over the whole surface of the plain. The latter is certainly the more probable theory, as the masses of quartz were cemented together by a calcareous cement of obviously a posterior formation to the quartz.

In which precise class of rocks, the above ought to be included, I have had no means of ascertaining; in their nature and structure, however, they resemble the rocks of the new red sandstone formation of *Jameson*, and I should feel induced to consider them as belonging to this class. No rocks of a similar nature have occurred to me during my march, nor do I think that, in the country passed after leaving this, any do exist, for in almost every situation the vertical strata appear at the surface, it is more than probable, however, that the rocks examined formed

a portion of a considerable formation which occupied the elevated plain under consideration, and which might extend in a northerly and southerly direction for a considerable distance. In Captain DANGERFIELD's map, a "granular coarse limestone" formation is laid down, as running from north to south the whole extent of his map, and passing in the neighbourhood of the plain in question. I have not seen any thing of this formation, it is not improbable, however, that the rocks just described, may be associated with it.

From Captain DANGERFIELD's map, it will be seen, that the communication now sent differs in many respects. In some instances, too, I suspect that we have called the same rock by different names. His sandstones and sandstone slates which he describes as skirting the western boundary of the great formation, may be the same as the rock here described as ferruginous quartzose sandstone; and his hornstone may be the stratified quartz so often mentioned in this paper. In some situations in *Méwar*, which I have visited, he has described as hornstone the same rock which I here call quartz—the very remarkable ravine which he mentions, as occurring at the bund of the *Udayasagar*, I have often seen, and the rock which is found there, and which he calls hornstone, is exactly similar to a rock of this part of the district, which I have classed with the stratified quartzes. That it is not hornstone, commonly so called, I have no hesitation in stating, and I cannot help thinking, that the adoption of such a name might give an incorrect idea of the formation in question, and might lead us to confound it with other formations. Where the quartz rock passes into clay slate, it might, perhaps, be named flinty slate. I prefer, however, retaining the general name of quartz, mentioning when it shall happen to pass into any other of the rocks, as for instance, into gneiss or granite, or mica or clay slates, into all of which in different situations it may be seen to graduate. Indeed, it appears to me, that the very large proportion

proportion of quartz, both as an ingredient in the compound rock and in an unmixed form, is a very striking feature in the geology of this portion of India, and one which ought not to be lost sight of. I shall take the first opportunity of forwarding to the Asiatic Society specimens of the rocks found in this district, which, I trust, will bear me out in the opinion which I have stated. In Captain STEWART's account of the strata between *Baroda* and *Mhow*, no mention is made of any overlying rocks on the west side of the great formation, neither does the succession of rocks laid down by Captain DANGERFIELD, appear to have been observed by him.

By the above remarks, I do not wish to detract from the well earned merit of Captain DANGERFIELD. We are indebted to him for much very valuable information, but to make a perfectly correct geological map of this part of the country would require years of minute investigation, and in a climate like this could scarcely be effected by one individual—too much praise cannot be given him for what he has done.

Proceeding in the usual direction, we reach the village of *Pit*, in the *Dungerpur* district, which stands eight miles distant from the last. Immediately on leaving camp, the country became exceedingly broken and uneven, and numerous small rounded hills were seen exhibiting at their surface the vertical strata—quartz rock was still observed, but clay slate was the preponderating mineral. In a well near camp, in a low situation, clay slate was also seen. The clay slate was, in some situations, of a quartzose nature, and in others it approached to chlorite slate.

Ten miles distant from *Pit* stands the *Bhīl Pāl* of *Ghātah*—for the first three or four miles the country was exactly similar to that just described, the jungle then became thicker, the country more broken and rugged,

1. and, though the hills with which it was studded were still low, the scene was rocky and wild in the extreme. The hackery road, which is tolerably good, passes through a narrow Ghat, I proceeded myself by a higher route, winding along the edge of the ravines with which the country was intersected, and passing over the tops of the hills. The rocks were every where observed at the surface, and the almost perpendicular sides of the ravines presented to the view excellent sections of the strata. We encamped on an elevated plain surrounded by ranges of low ridge-shaped hills. Since leaving *Birpur*, we have been gradually ascending, and the ascent of the last six miles has been much greater than usual. The rocks observed were different modifications of quartz, varying in color from pure white to a very dark brown. The pure white variety has not yet been seen regularly stratified, beds of it, however, alternate with other rocks, and these beds are traversed in every direction by seams and cracks, and have the appearance of being made up of a congeries of detached masses, varying in size from two or three inches to a foot in diameter, and closely connected together. The colored varieties are distinctly stratified and are arranged in parallel layers, varying from an inch to a foot in thickness. Their color depends on an admixture of the rocks with which they are associated, sometimes in very small proportion, and at others the proportion is considerable, many of them, too, derive their color from iron—the dark brown variety is a ferruginous quartz, very rich in this metal. Iron appears to be an abundant production in the country we have been describing, and several pretty good specimens of the magnetic iron ore presented themselves. The above quartz rocks were seen alternating with clay slates—in some situations soft and friable, in others quartzose—and chlorite slate. The chlorite slate was first seen three or four miles distant from *Pu*. About half way between the last mentioned place and *Ghat*, we passed a small hill composed of serpentine. It was not stratified. The bed in which it occurred appeared, as far as

I could judge, of considerable extent, and in this part of the country I know it to be an abundant production. It was of a greenish colour, with a tinge of brown and grains of a metallic mineral, with a metallic lustre were disseminated through it. This was magnetic iron ore.

The clay slates passing into chlorite slates were the preponderating rocks, and in the neighbourhood of our camp these appeared to pass into mica slate, small scales of mica being disseminated through them.

We now proceeded to *Sagwára*, twelve miles north-east of the last. The country on leaving *Ghata*, became more open, and, though still uncultivated, was comparatively free from jungle. The line of march lay over the tops of the small hills which were still very numerous, and we had thus pretty extensive views of the surrounding country. It presented a waved, or rather mamillary aspect, and several small ranges of low ridge-shaped hills were observed. Mica slate, and mica slate approaching to clay slate, were almost the only rocks observed.

We next proceeded to *Jariána*, a *Bhil Pál*, sixteen miles from the last. The country was still completely studded with low rocky hills—for the first three or four miles mica slate preponderated, after this the hills were almost entirely composed of pure white quartz, in which occasional scales of mica were observed, but these were rare. This rock every where appeared at the surface, giving to the scene a striking and peculiar aspect, and were it not for a hot burning sun one would almost be inclined to believe that the country was covered with snow. No other rock made its appearance, except an occasional bed of mica slate of inconsiderable extent—many of the masses of this quartz were nearly transparent and approached to rock crystal, and others had a slight rose tinge. It was either compact or large granular, the concretions being about the

size of a large bean : It occurred stratified, and, though the strata were not very distinct, the stratiform structure was sufficiently obvious. In dip and inclination it agreed with the other rocks seen. The whole surface of the country is covered with detached masses of this rock, and very frequently immense isolated blocks, of several yards in diameter, were seen topping the hills, and these, in many situations, were piled upon one another in a very fantastic manner. In the neighbourhood of camp was a group of conical hills, higher than the rest : these were formed of a micaceous clay slate.

Proceeding onward to *Jaitana*, in the *Udayapur* district, the country becomes more open, and plains of considerable extent are seen. There were still, however, numerous small rounded hills, while others assumed a conical form and others were ridge-shaped. The preponderating rocks were mica and clay slates, in which large beds of the white quartz occurred. *Jaitana* is six miles distant from *Jaríána*.

We now marched to *Salúmbhar*, a walled town of considerable extent, belonging to one of the principal Omrahs of *Udayapur*, and situated eleven miles N. W. from the last. The mica slate, during this march, passed into gneiss, in which beds of granite, some specimens containing chlorite and hornblende slate were observed. From *Jaitana*, a range of hills were seen in the distance extending N. W. and S. E. *Salúmbhar* is situated at the base of this range, which is connected with the one which passes the *Dhábar*. The hills are generally ridge-shaped, and sometimes peaked, and those in the neighbourhood of the town are fortified.

In the nullah courses a very thick bed of kunkur, of a distinct rocky structure, and indistinctly stratified, was observed. The kunkur formation now becomes very abundant—it is differently modified in different situations—

situations—it is sometimes soft and friable, at others it is more crystalline—it occupies the highest situations as well as the lowest. This formation appears to me to be one of great importance, and, if examined on a large scale and described with minuteness might lead to very interesting results. When it rests upon the softer rocks, as clay slate, it is frequently seen penetrating into their substance, the water which held it in solution having percolated through the strata and deposited the lime in the form of calcareous spar in their interstices, so that these rocks at their surface are almost entirely converted into a calcareous rock, inattention to this circumstances may sometimes lead into error. Iron pyrites is very generally distributed through the mass, and rounded portions of various rocks are found imbedded in it.

We next proceeded to *Gingla*, a small village, twelve miles north west of *Salúmbhar*. On leaving the latter town, the country becomes very rocky and uneven, and exhibits the mamillary aspect so often alluded to. On the left hand the *Dhábar* range was seen stretching north-west and south-east, and other range of lower hills, running in the same direction, was seen on the right. These hills are generally ridge-shaped, some times peaked, and at others conical. The *Dhábar* lake was seen washing the base of the rough and craggy hills on the left. For the first half of this march gneiss passing into granite, generally of a red colour, with occasional beds of hornblende slate and quartz, was seen. The hornblende rocks then preponderated, and these and the granite rocks formed frequent alternations. *Gingla* is situated on a hill, composed of hornblende slate passing into greenstone, and in the neighbourhood are a number of small hills composed of a similar rock. The soil where these rocks occur is of a red colour, derived from iron which exists in them in great abundance, and the surface of the strata is covered with a thin brown crust, (carbonate of iron,) derived from a similar source. Occasional beds of gneiss,

of

of a grey colour, small grained, and not stratified, occur in this formation. This gneiss is composed of dark coloured mica in minute scales, a felspar slightly tinged with red and translucent quartz. In the hornblende rocks, which are distinctly stratified, I observed a vein composed of felspar and quartz—the latter, clear and nearly transparent, the former, a pale reddish white, with perfect foliated fracture, and crystalline structure arranged so as to form a kind of porphyry.

We now marched to *Katáwar*, a pretty large town, with a fort, twelve miles north-west of the last. The *Dhábar* range was still seen on the left, and the country presented the usual mamillary aspect. The rocks observed were different modifications of granites, hornblende slate and chlorite slate—all these alternating with each other. The line of march in one situation approaches the range of hills, and a similar variety of rocks could be distinctly traced in their base and rocky slopes. The granitic rocks were, 1st, A gneiss of a greyish colour similar to that described at *Gingla*. 2d, A red granite, the principal ingredient a dark flesh red felspar—the quartz is in minute quantity and is translucent, and the mica of a dark color is in still smaller proportion. 3d, A reddish coloured gneiss. 4th, A rock, with the distinct structure of gneiss, of a greenish grey colour, in which the mica is replaced by hornblende; and 5th, A rock almost entirely composed of flesh red felspar, with a foliated fracture, and in which are imbedded nearly transparent crystals of quartz. The latter rock, except for the first two miles, within which the hornblende rocks were principally seen preponderated. It was distinctly stratified—strata highly inclined and dip towards north-east—mica is very rarely seen in it, and indeed is almost wanting. It may be said to form a variety of porphyry, but from its stratiform structure and the arrangement of its component parts, I prefer including it with the granitic rocks, in which series it ought certainly to be classed, perhaps, as a distinct variety,

variety, which may be called granitic porphyry. It passes into the flesh red granite before described, in which granite chlorite often occupies the place of mica, forming the protogine of Jurine. The felspar of the latter rock is uniformly of a darker red color than that of the granitic porphyry.

We next proceeded over a very bad road to *Thanna*, a *Bhil Pál*, seven miles north-west of the last. The country presented the usual mammillary appearance of the lower granite tracts, but it was more broken and rugged than I had heretofore seen, and was traversed by numerous deep and narrow ravines. For the first three miles, the following rocks presented themselves; viz. the felspar rock, which I have called granitic porphyry, which passes in some situations into gneiss and granite, both generally of a redish colour. A granite composed of pure *white granular felspar*—translucent quartz and silver colored mica, was also observed in small quantity. Through this last garnets were sparingly interspersed. These alternate with different modifications of hornblende rocks; viz. hornblende slate passing into greenstone slate and primitive greenstone—the alternating beds are from fifty to two hundred paces in breadth. We then reached the bed of a nullah, with rocky banks, composed of a formation exactly similar in appearance to the waved gneiss—it contains, however, no mica, its constituent parts being hornblende, felspar and quartz—the latter, in small proportion. I imagined at the time that this rock was a distinct grey gneiss, and picked up several specimens of it as such. It formed now the preponderating rock in which beds, but not of great extent, comparatively speaking, of hornblende slate and greenstone were observed, beds of red granite, and in one or two instances, of chlorite slate were also seen.

The above described rock exactly resembles the close grained grey gneiss. It had a waved appearance, and it was only on reaching camp,
B 2 and

and examining my specimens that I discovered its true composition. It may be called sienitic gneiss. It was distinctly stratified and dipped towards the N. E. This formation is continued for several miles in the direction of the Residency at *Minta*, at which place I arrived next day. The geology of the last march I shall not enter into at present, as I propose drawing out a "sketch of the geology of the valley of *Udayapur* and its neighbourhood," in which this portion of the country will be included.

In conclusion, I would again call your attention to the regularity of the gradation observed from the rocks seen on leaving *Birpur* to those in the neighbourhood of *Udayapur*. They pass into each other by almost insensible degrees, so that it is often difficult to say, in which class particular specimens ought to be included. The granitic rocks,—except the very large granular variety of *Pandua*, which I have supposed to be a very old granite—are, generally speaking, small grained, or intermediate between small and large.

These remarks, such as they are, I do myself the pleasure of forwarding to the Physical Committee of the Asiatic Society, and I have to regret, that the season of the year at which I travelled; viz. during the hot winds, prevented me extending my observations so far as I could have wished. This circumstance must plead my apology for the imperfect nature of this communication. I have avoided entering into any details connected with the character, &c. of the inhabitants of the country through which I have passed: this would have extended my paper to an undue length: this, however, I must say, that I have experienced nothing but civility from the rude and barbarous tribes among whom I have travelled, and, though the names of *Bhil* and *Coleah* have always been associated with those of plunderers and robbers, I have met with more
attention

attention from these very tribes, than I have ever experienced in other parts of India. The chiefs (9 *Ométí's*.) of their *Páls*, frequently visited me—they appeared to have a great deal of curiosity, examined every thing about my camp—asked various questions about the uses to which they were applied, and on the whole, I was much pleased with the rude inhabitants of this wild and mountainous portion of *Hindustan*.

The route by which I have marched is not the common one, I have no hesitation, however, in recommending it to travellers who may be proceeding from *Bombay* to *Nímach*, as by far the shortest and the best. From *Baroda* to *Nímach*, via *Bírpur* and *Salumbher*, there are only eighteen or nineteen ordinary marches.

The accompanying section of the strata from *Baroda* to *Thanna*, I do not offer as perfectly correct; it will serve, however, to give a general idea of the geology of the tract in question. In a plan on so small a scale, I could only indicate the rocks which preponderate in particular situations, and no attempt has been made to lay down the beds of other rocks with which these are associated, and with which they frequently alternate.

V.

ON THE DIAMOND MINES OF PANNA IN BUNDELKHAND.

By CAPTAIN JAMES FRANKLIN,

First Bengal Cavalry, M. A. S.

(WITH A MAP.)

THE geological position of the matrix of the diamond, being still a question in the history of that gem, the following notice on the diamond mines of *Panna*, will not, I trust, be unacceptable.

Report says, that they were first* discovered in the time of Raja CHITRASÁL, who ruled at *Panna*, in the reign of the Emperor AURANGZEB, but

* Their discovery is attributed to a Devotee of the *Mehdivi* sect, who established his doctrine at *Panna*, in the time of Raja CHITRASÁL, or about A. D. 1680-90, I doubt this statement, but I cannot arrive at satisfactory proof of their previous discovery. Mr. MAWE dates the discovery of the mines of *Brazil* about the same period, and Dr. HEYNE has a similar account of some of those of *Golconda*, but TAVERNIER says, that the Mogul diamond was found at *Color*, not far east of *Golconda*, A. D. 1550.

BOETIUS DE BOOT published his treatise "De Lapidibus et Gemmis," A. D. 1609, and points out the diamond mines of *India* and *Malacca*—and in fact, it appears, that the diamond has been found in India in all times, since the days of PLINY, and, perhaps, long before.

but that period being a troublesome æra in the annals of the *Bundelas*, it is supposed, that they were not efficiently opened, until the time of his grandson SUBHA SINHA.

Their situation is peculiar, being confined to a small portion of the great belt of sandstone which extends from *Rotásgerh*, through the provinces of *Boghélkhand* and *Bundélkhand*, until it is finally covered by the overlying trap of *Malwa* and *Ságar*; this, however, is but a small part of the extent of this formation, for the break at *Rotásgerh* is merely an hiatus occasioned by the original current of the *Sona* valley, which doubtless swept away every vestige of this rock, until its force was turned aside by the projecting points of the *Vindhya* range, near *Monghir*—after which, in the *Rájmgahal* hills, the sandstone again appears as before—and from that point it may be traced throughout the whole of the peninsula; it is the depository of the diamond at *Panna*—and I have, no doubt, that the rock mines both of *Sembhelpur* and *Banganpalli*, though far asunder, will ere long be found to belong to the same formation; in the mean time, the following facts which have fallen under my own observation, on my route from *Belári* to *Ajayagerh*, may serve to identify the class and character of the rock which contains the matrix of the diamond of *Panna*.

The *first part of the route (or from *Belári* to *Ajayagerh*) crosses the most lofty portion of the sandstone belt, usually called the *Bandair* hills—which, without exception, is entirely composed of argillaceous sandstone, either mottled or streaked—and opposite to the village of *Piperiya*, below the Ghat of that name, I observed the sandstone reposing on beds of slaty marl.

Having

* See the map which is appended to my paper on Geology, Art. 2d, of this volume; also the description of these hills in that article.

Having descended the *Bandair* hills by the Ghat of *Piperiya*, I came upon the second range, which like the former, is also composed of sandstone, but the surface of its plateau being covered with a stratum of lias limestone, the sandstone can only be traced in the beds of rivers, or in small protruding elevations, until it emerges from beneath the limestone and forms the counterscarp of the *Panna* hills, where it is variegated and friable, and the marly slates are again visible in the hills which overlook the town of *Panna*.

The lowest portion of the range, or that which is called *Bindūchal*, is the peculiar habitat* of the diamond, for it is not found in any other part, except on the platform of this range, or on the counterscarp of the second, and it is proved by the waterfalls, that this range also is entirely composed of sandstone.† For instance, the cascade of the *Ranj* river shews a series of sandstone interstratified with slate clay three hundred and ninety feet thick. All the other waterfalls present similar appearances, and that of the *Bāgin* river, penetrating deeper than the rest, exhibits a fine section; here the sandstone is distinctly interstratified by a succession of layers of slate clay, the uppermost of which having a marly base is thickest, and the descending strata becoming more indurated, containing more mica, and gradually diminishing in thickness, dwindle away finally into mere partings, and in their progress to this attenuated state, they

* The diamonds found in the glen of the *Bāgin* river are transported diamonds, they are not, therefore, an exception to this rule.

† See the map appended to this paper.

‡ The sandstone of the *Bindūchal* hills rests as on a point d'appui upon a low ridge of syenitic granite, which has, probably, saved it from being swept away. The bases of the forts of *Kālenjara* and *Ajayagerh*, are of this rock, and are merely capped by sandstone. The same may be said of the scarp of the great range, but if the granite ridge be crossed by entering into any of the glens, the sandstone will be seen to be at least four hundred feet thick after the ridge is passed.

they assume characters so various, that in some instances, it is difficult to distinguish them from the older schists. The sandstone also changes, gradually becoming *silicious, and at the bottom it closely resembles some varieties of quartz rock, but the horizontal position of the beds is constantly preserved, and in all the glens, particularly in that of the *Bágun* river, black bituminous shale crops out from beneath the sandstone. I excavated this shale to the depth of six feet,—but having no other means than such as I could procure on the spot, the influx of water soon overpowered my operations. I found, however, that the bituminous quality of the shale increased,—fragments of it, throwing out strong shoots of flame when ignited, and I was disposed to think that coal was not far distant.

I have ventured to call this formation *new red sandstone*, considering it in the same light as the series of rocks so termed in *England*, and it would appear, that this denomination is in some measure corroborated by other facts, in other portions of the same range of hills, but principally by the proof of its saliferous nature. It has been shewn, that at the village of *Kattra*, the soil is impregnated with salt, which is there, and in many other adjacent villages, extracted by the native process of lixiviation, such is the case also on the banks of the *Tons* river, and Mr. STIRLING, who published an account of the diamond mines of *Panna*, remarks, that salt abounds in the soil at the foot of this range, opposite *Allahabad*, and between that place and *Mirzapur*. These facts, therefore, together with

* I observed the same circumstance in the waterfall of *Bowla*—See Art. 2d of this volume.

† Art. 11th of this volume.

‡ See *Oriental Quarterly*, No. — Page — Mr. STIRLING did not visit any other mines than those in the immediate vicinity of *Panna*; and Dr. HAMILTON, who has published an account of these mines in the *Edinburgh Philosophical Transactions*, vol. 1, distinctly says, that he did not even go so far as *Panna*, and could not have seen any other than a few superficial mines, at the top of the *Bisramganj* Ghat.

with the general horizontal position of the beds, the existence of lias limestone reposing upon them, the distinct interstratification of a series of slate clay, and above all, the cropping out of bituminous shale from beneath the whole mass, would appear to justify the use of the term which I have applied.

I have been thus prolix, because it is of importance that I should be clearly understood with regard to my nomenclature, and, if I am wrong, my own description may, perhaps, serve to correct my error. Having thus premised, I shall now proceed to give as brief a description as I can of the mines in question.

The natives describe the mines by using the terms *chila*, or superficial, and *gahira*, or deep, and the matrix they call *madda*; the rocky matrix of the deep mines is always a conglomerate, and, if it is a gritstone with a silicious cement, and its pebbles are of ancient rocks, and waterworn, it is termed **pakka*, or mature; but if the cement is argillaceous, and its pebbles are of more recent rocks, it is then called *kacha*, or immature; the matrix of the superficial mines is universally called *Lalkakru*, or red ironstone gravel, mixed with ferruginous sand or clay. This gravel is waterworn and sometimes quite rounded like swan shot, and when found in the fissures and interstices of the upper sandstone, it is mixed with ferruginous sand, but on the other hand when imbedded in ferruginous clay, it is usually found covered with vegetable soil and reposing upon slaty marl;—sometimes, however, it is surmounted by a stratum consisting of particles of common

* As at Panna, Kamariya, Brijpur, &c.

† As at Sakeriya and Udesna.

‡ As on the counterescarp of the Panna hills.

§ At Panna and Kamariya.

common *kankar* imbedded in yellow clay, which occasionally mingling with it, forms, another *description of matrix which being calcareous, is called *hadda*; the diamonds of the glen of the *Bágin* river, have evidently been transported thither from their native beds, and in all probability the gangue in which they now rest in the basin of the waterfall, greatly resembles the *cascalho* of the Brazils, or that of *Sambhampur*, in Southern India.

The *pakka*, or rocky matrix, is very limited, stretching generally from *Kamariya* to *Brijpur*, along the course of the *Bágin* river. It is excavated at *Kamariya*, *Bijipur*, *Bargari*, *Myra* and *Etwa*; there is also a small deposit of it near the town of *Panna*, but at *Brijpur*, from the effects of denuding causes, it lies at the surface, and a very satisfactory section of it is laid bare in the bed of a small rivulet about one mile west of the village, where it appears to be a gritstone, composed of white quartz gravel, cemented by silicious matter; and containing rounded pebbles of quartz, jasper, hornstone, lydianstone, &c. Thus it forms a conglomerate, which passes by gradual transition into silicious sandstone. It is readily distinguished from its associated rock, differing greatly from it, in as much as the sandstone in which it is found, has a martial argillaceous cement, and closely resembles that which forms the upper layer of the cascade of the *Bágin* river.

Kamariya Mines.

The most noted mines of this description of matrix are those of *Kamariya* and *Panna*; at the former place they are on an average about fifteen feet deep, and in one which I examined,* the beds of slaty marl were

two

At *Dangla*, *Bakhtapur*, &c.

two feet below the surface, a thin stratum of red ironstone gravel imbedded in ferruginous clay, and vegetable soil, were their only covering; they differed in no respect from those of *Piperiya* Ghat, they were marly, slaty, slightly micaceous, interstratified with thin laminæ of sandstone, and associated with calcareous slates, which were dendritic between their partings, and although their general colour was bluish green, or greenish grey, yet there was a sufficient mixture of red to characterize them; they were about twelve feet thick, and immediately below them was the rocky matrix of the diamond.

The conglomerate is here as at *Brijpur*, a gritstone containing pebbles of quartz, both white and *green, jasper, hornstone, lydianstone, &c. and it is worthy of remark that when the green quartz pebbles abound, it is considered a good sign, and so also when the gritstone is slightly ferruginous, the matrix in these mines reposes on compact sandstone.

Panna Mines.

The mines of *Panna* are of the same kind: here also the stratum beneath the vegetable soil is red ironstone gravel, below which are beds of slaty marl, better characterized if possible than those of *Kamariya*, then follows the †diamond matrix, which differs in no other respect from that of *Kamariya* or *Brijpur*, except that it appears to contain a little more ferruginous

* The green quartz is exceedingly brittle and splintery, the natives call it *Kanchiyz*, or glassy.

† It is worthy of remark that both this matrix and that of *Kamariya* inclose fragments of schist, which M. CHARPENTIER calls *schiste argilleux terreux jaunâtre* (see his *Essai sur les Pyrénées*, page 297.) I have seen this rock in situ at *Betharam*, at the entrance of the valley of *Barej*, a small specimen of which accompanies this paper, but I have not as yet been able to trace it in situ in India. At *Betharam*, it is on the summit of a hill, the base of which is formed of Ophite, a rock of the trappean family, so named by M. PALASOU—it has also a great resemblance to burnt clay, so named in Wernerian collections of minerals, as for instance in that presented to the Society by the late Dr. ABEL.

ferruginous matter ; its pebbles are the same, its cement the same, it has the same peculiarity of containing green quartz nodules so highly esteemed as an augury by the natives, and its floor is of the same description of sandstone.

These mines vary in depth from twenty to fifty feet, and owing to the stratum of the matrix being thinner (sometimes scarcely a span thick,) they cannot be worked laterally as at *Kamariya*, they are therefore more expensive, but their produce is said to cover the outlay and yield a profit. They are consequently esteemed, and hold a reputation nearly equal to those of *Kamariya*.

Sakeriya Mines.

The *kacha*, or immature matrix, is excavated at the villages of *Sakeriya* and *Udesna*, both situated on the counterscarp of the *Panna* hills. It contains rounded pebbles of quartz, jasper, lydianstone, &c., but with these are mixed more recent pebbles of white sandstone. It contains also much white quartz gravel, called by the natives *detla*, but the cement of the conglomerate instead of being silicious is a yellowish white clay, soft and plastic when in its natural bed, but capable of acquiring the consistency of mortar when exposed to the atmosphere, and when it contains ferruginous matter it is considered a good sign. The quartz pebbles are of the fat and greasy variety, and the green kind so much esteemed in the rocky matrix, is here entirely wanting.

A shaft near *Sakeriya* which I examined, pierced through the following beds ; 1st, eight feet vegetable soil ; 2d, eight feet *piri matti*, or common *kankar*, imbedded in yellow clay ; 3d, four feet *lalkakru*, or red ironstone gravel in ferruginous clay ; 4th, two feet *detla*, or white quartz gravel ; next followed sandstone, and then the *kacha* matrix ; The thickness of the

detla

della stratum is here considered a matter of augury; if it is too thick it augurs ill, as it is then supposed that the stratum of *madda* will be correspondently thin, or wanting altogether;—It ought not to exceed two feet.

Udesna Mines.

Near the village of *Udesna*, the same kind of matrix underlies *laterite, there called *macha*; the great abundance of ironstone gravel and ferruginous matter strewed over this part of the country necessarily produced in former times, and no doubt still continues to produce, a great quantity of oxide of iron, which being washed away, and held in solution by the minor streams, has been gradually deposited in the channel of the *Ranj* river until it is now about ten feet thick, and immediately below it are the beds of *della* and sandstone, and the matrix as above mentioned. This matrix does not require to be broken, the clay is easily separated by washing, and the expense of working the mines is consequently lessened, but still they are not considered so certain in their return as those of the rocky matrix.

Superficial Mines.

The *chila*, or superficial mines, are to be found in every part of the diamond tract, excepting only a circuit of about five miles from the cascade of the *Bágin* river, where it appears that denuding causes have swept

* The laterite is an aggregate of ironstone gravel cemented by an argillo ferruginous cement, it therefore somewhat resembles pisiform iron ore; the great mass must have been formed by diluvial agency, but it appears to accumulate by alluvial action also—for the natives assert that the stream is reddened in the rainy season;—as there has not, however, been any sensible increase of it in the memory of man, I conclude that its alluvial accumulation must be very imperceptible.

swept them away and all their contents into the glen of that river. Their matrix is always red ironstone gravel in ferruginous sand or ferruginous clay. Their geological position with regard to the descending series, appears to be remarkably well defined, for they are actually to be found on the verge of two *cascades, having 400 feet of sandstone beneath them; when this matrix fills the fissures and interstices of the upper sandstone, angular fragments of the rock are mixed with it, the corroding influence of the oxide of iron appearing to have detached them as well as to have desintegrated and oxidated a portion of the rock so that the gravel and fragments are imbedded in sand so highly ferruginous that it resembles the rust of iron; but when on the other hand it is imbedded in ferruginous clay, it contains no fragments of sandstone, and is constantly found overlying slaty marl or sandstone, or *della*, as in the instances above mentioned; with regard to the ascending series its geological position seems also to be well defined, for if the two strata of red ironstone gravel and *kankar* occur together, as they do at *Sakeriya*, it always underlies the †calcareous bed, and their line of separation is distinct so that when they happen to mingle as at *Bangla*, the matrix acquires a new name, and is then called *hadda*.

These mines rarely exceed five or six feet in depth, and are often much less; with regard to their produce I am inclined to think that they are very precarious, notwithstanding some of the largest diamonds have been found in them; it is common to hear complaints of having found
nothing

* On the verge of the cascade of the *Ranj* river near *Ránipur*, and on that which is near to the village of *Bakhtapur*.

† The fact of the production of laterite in the bed of the *Ranj* river, and the circumstance of ironstone gravel underlying, and consequently, preceding common *kankar*, are useful facts in Geology.

nothing for many months, and to me they appeared like a lottery in which there are a few prizes and many blanks—they have an advantage in requiring little or no outlay, and are consequently wrought by all classes, but it is not unlikely that more capital has been sunk in them in the shape of labour than has ever been returned.

The diamond is occasionally, though very rarely, found on the surface, nor is it improbable that some lucky chance of this kind may have led to the discovery of the mines.

Mines of Transported Diamonds.

The above is a brief account of all those matrices of the diamond in the *Panna* district, which fall under the denominations of *mudda*, *lál-kakrú*, or *hadda*; but there are others where the gem is found in deposits with which it appears to have been swept away from its native beds, as at *Majgoha* and in the glen of the *Bágin* river; the mines of the former place are peculiar and require separate mention, but in those of the glen, the diamond is found under rocky debris, both on the banks and in the bed of the river, and also in the basin which receives the cascade: its matrix in this state is a confused mixture of red ironstone pebbles, angular fragments of sandstone, and pieces of common *kankar*, heaped together in ferruginous sand or clay, the detritus in fact of its original gangue; and the mines of course have a great resemblance to the superficial mines above-mentioned, but they are said to be rather more productive, and there is great reason to believe that the basin of the cascade has never yet been emptied or excavated except to a trifling extent.

Majgoha Mines.

The mines of *Majgoha* are in the western part of the diamond tract, and they may properly be called its western boundary; they are situated
in

in a hollow resembling an inverted cone, which appears to have been excavated by the same process (more powerfully applied) which scooped out those resemblances to it in miniature, which are observable in the rocky beds of rivers, the diameter of the vortex is about 100 yards, and its depth (I presume) cannot be less than 100 feet; on its periphery, superficial mines are wrought in sandstone, but the cavity of the chasm is filled with green mud, containing calcareous matter, such as I can find no apt similitude to, except by supposing it to be the abraded matter of the same marly slates as those which occur in the mines of *Panna* and *Kamariya*, here deposited en masse, and there in slates; this of course is mere conjecture, but if the vortex has been formed as I suppose it to have been, the matter could not in that case have acquired a schistose form; be the facts of the case however what they may; this singular deposit fills two-thirds of the chasm, and at the top it has a thick crust of calcareous spar, which is indistinctly stratified, and contains portions of the green mud between its laminæ.

The diamond is rarely found in the calcareous crust, its habitat being in the green mud, and it is believed by the natives, that the deeper a shaft descends, the richer is the produce; but although they are aware of this circumstance, their ordinary means have never enabled them to descend lower than fifty feet, the water at that depth overflowing their works, and compelling them to desist: this deposit, therefore, and that of the basin of the *Bágin* river, appear to be two instances in which superior means might be employed, with effect, and perhaps with profit.

Mode of washing and searching the Matrix.

The mode of washing and searching is the same in all the mines, the rocky matrix alone requiring to be broken; it is first thrown into a
trench

trench with water and shoveled and trod like mortar, and as the object is to wash away the clay, fresh water is thrown on and poured off repeatedly until the fragments are sufficiently cleansed, and as a final purification they are sifted on fine baskets which completes the operation of washing, they are then spread in a thin layer on a smooth floor plastered with clay or cow dung, and when dry the whole is passed under the hand, and searched three several times, after which the fragments are thrown aside.

Reproduction of the Diamond.

The circumstance of diamonds being frequently found amongst these fragments after they have been thrown aside, has, perhaps, given rise to the idea of their reproduction, and I was anxious to obtain the opinion of experienced natives on this subject: they admit it only in one instance, viz. at *Majgoha*, and even there, it is always ascribed to the spiritual agency of the founder of the *Mehdivi* sect, to whom those mines belong, but their more rational opinion is as follows, which I will give as nearly as possible in the words of my communicant. “The object of washing is to free the rocky fragments from clay, and particularly to cleanse the diamond, so that it may readily be distinguished in the operation of searching, but with all our care we cannot always succeed; small diamonds frequently retain their covering, and thus elude our search in the first scrutiny, nor can they be discovered afterwards, until the coating which concealed them is worn away; hence it happens that diamonds are found amongst fragments which have been searched and thrown aside, but it is observable that small diamonds alone are so found, and that they rarely exceed the weight of half a troy grain.”

With regard to *Majgoha*, I am inclined to think that the above opinion applies with greater force. The matrix of these mines contains calcareous matter,

matter, and it is no easy attainment to wash away a calcareous incrustation by using water alone, whenever therefore, such an occurrence takes place, the diamond might not only elude a first search, but a series of searches, and even for a series of years, until the coating which enveloped it, was worn away.

Description of the Diamonds.

The diamonds of the *Panna* mines may be classed, according to the following arrangement, using native denominations : 1st, *Lilwaja*, transparent, colorless, having no tinge except the azure which is reflected in a drop of distilled water, it is so scarce that only one specimen was to be found in the town of *Panna*.

2nd. *Banspati*, *Motichar*, *Ghiya*, or *Maska* : these kinds are common, the first has a greenish tinge, the second is also greenish, but varies to a pearly cast ; the third is yellowish and of a greasy or resinous lustre, as its name implies ;—the crystalline form of this class is very distinct, exhibiting frequently the regular octahedron as perfect as if it had been shaped by an artist, the dodecahedron is also common, and so is the spheroidal, arising apparently from the convexity of its faces, and the obtuseness of its edges the average price of this class is thirty **Srinagari* rupees, for diamonds of one *retti* weight 35 for two, 40 for three, 45 for four, and 50 for those of five *retti* weight.

3d. *Sambarra* and *Charchara* : these are they which have given rise to the belief that the *Panna* mines produced only table diamonds, the specimens

* The *Srinagari* rupees is about ten per cent. less in value than the Sonat rupee, consequently it is about fourteen and a half or fifteen per cent. less than the Calcutta Sicca.

specimens I saw were quite irregular in their crystalline form, appearing as if they had been broken by a violent blow, but they invariably cleave into thin tabular laminae, and as they are generally of a good water, and sell for a low price in comparison with the others, the *Panna* jewellers appear to find it more profitable to work them up, by setting them in rings or other ornaments; their one *retti* price is twenty rupees, increasing according to weight as above stated.

4th. *Bengala pashmi, Pira* and *Matta*: these are yellowish green, yellow, and clove brown, and their crystalline form is multiform, the price of the one *retti* gem is fifteen rupees, increasing as above.

5th. *Rekatberar*: this is the rose coloured variety, its crystalline form is ~~also~~ multiform, it is not esteemed, and its single *retti* price is twelve rupees.

6th. *Kāla, Garas, or Jalidar*: the first is black or very dark brown, and the second as its name implies, includes all diamonds that are flawed or appear to continue filaments like a spider's web: these varieties are here termed *Kaffiya*, or scum, but in *England* they are called *bort*, and there they are used in the arts for diamond dust to an extent unknown in this country, their price varies according to the size of the stones: but as they seldom, if ever, exceed one *retti* weight, the worst kind may be purchased for eight and the best for ten rupees the *retti*.

The above list contains the principal names classed according to their relative value, but there are others, apparently founded on fancy alone, a recital of which would embarrass rather than throw light on the subject; the prices also must be considered variable, a purchaser coming suddenly into the market would as infallibly occasion a rise, as a deficiency of demand

demand would create a depression, a purchaser therefore should fix himself on the spot, and make his purchases gradually, by so doing, he would at least save the profits which now go to the merchants of *Benares*.

Revenue of the Mines.

The revenue of the mines is divided among the Rajas of *Panna*, *Banda*, *Chircari*, and *Jaitpur*, but by far the largest share belongs to the former. According to my calculation the *Panna* division amounts to about 26,000 Rupees per annum, but according to Raja PERTAB SINH, who is the efficient manager of the *Panna* state, it is 30,000 Rupees, and as his authority is likely to be nearer the truth than mine, I do not hesitate to adopt it; this revenue is derived from a *tax, originally fixed at one-fourth of the value of all diamonds found in these mines below a certain weight, which, I believe, was rated at eight *rettis*, but the tax now levied is said to exceed this rate, and on diamonds above the eight *retti* weight there is no stipulation, taking therefore the aggregate of the *Banda*, *Chercari* and *Jaitpur* shares, as equal to a fourth of the revenue derived by the Raja of *Panna*, it will not be too much to suppose that the produce of the mines amounts to about 1,20,000 Rupees per annum.

I have now detailed with the utmost fidelity all the circumstances relating to these mines as they occurred to me at the time I examined them,
and

* The tax of 25 per cent. was fixed in the best days of the mines, when the produce was greatest. They are now, however, on the decline, and the natives are quite aware of the circumstance; the superficial extent of the *pakha* matrix appeared to me to be traceable, and consequently the question of its quantity falls within the range of reasonable calculation, whether the natives have drawn their conclusions from this view of the case, or whether they are influenced in their judgement by experience, arising from the natural result of their draughts from an exhaustible source, I do not know, but to me it appeared, that these mines by the employment of a given force, might be exhausted within a given time, and that there is no hope of finding diamonds below the bed of the *pakha* matrix.

and have endeavoured to throw into my narrative as much perspecuity as the subject is capable of; still, however, the diamond is too important a mineral to be passed over in a hasty manner, and I trust I shall be excused if I here indulge in a few general observations.

General Remarks.

1st. It was formerly supposed that diamonds were always found at the *same level above the sea, and it still remains to be proved whether or not there is any truth in the hypothesis, the following barometrical heights are deduced from actual observations made by myself.

Kacha Matrix.

Source of the <i>Ranj</i> river near <i>Udesna</i> ,	1496 feet.
Floor of the mines of <i>Sakeriya</i> and <i>Udesna</i> ,	1470 „

Pakka Matrix.

Floor of the mines near <i>Panna</i> ,	1300 feet.
Bed of the <i>Ranj</i> river due east of the above,	1300 „
Top of its cascade near <i>Ranipur</i> ,	1240 „
Source of the <i>Bágin</i> river near <i>Urki</i> ,	1420 „

Floor

* This hypothesis can only apply to diamonds in their native or rocky beds, and does not of course refer to transported diamonds which are found at various levels, but if the rocky matrix is universally confined to sandstone of the same era, it is not unlikely there may be some truth in it, at least in India, for instance, the rock mines of *Banganpilli* appear to correspond pretty closely with those of *Panna*, and Captain CULLEN (Madras Lit. Trans.) says, that “the route across the plain between the nalla malla range and the table land at *Banganpilli*, is about 800 feet above the sea;” now the town of *Banganpilli*, from its position with regard to two rivers, (the *Kund* and the *Suru*) which unite in that plain, must be still higher, and Dr. HEYNE says, it “is built at the foot of a low ridge of hills—from 100 to 200 feet perpendicular height on which the diamond mines are situated.” Dr. HEYNES estimate of the height of the diamond ridge is conjectural, and may, as is often the case, in estimates of height made by the eye be rated too low—upon the whole, therefore, I think, there is reason to conclude, that the diamond bed of the *Banganpilli* mines is at least 1100 feet above the sea.

Floor of the mine of <i>Kamariya</i> ,	1380 feet.
Bed of the <i>Bágin</i> river due south of them,	1380 „
Floor of the mines of <i>Brijpur</i> ,	1260 „
Bed of the <i>Bágin</i> river exactly opposite,	1250 „

Matrix swept away.

Top of its 1st cascade,	1120 feet.
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Transported Diamonds.

Bottom of 1st cascade,	900 feet.
Bottom of 2d cascade,	700 „

From this list it would appear that the rock matrix of the diamond in the *Panna* mines has been swept away at an elevation of 1100 feet, and that its lowest position in situ is between 12 and 1300 feet above the sea.

2d. The contracted limits of this diamond tract has already been mentioned, as a peculiarly striking circumstance; the same kind of sandstone as that in which the diamond is found, extends far beyond those limits and why does it not contain diamonds also? to this question I can only reply by the following explanation; *on the north*, the scarp of the *Bindáchal* hills rests as a point d'appui on a low ridge of sienitic granite and the plains of *Bundelkhand* exhibit primitive rocks throughout—therefore excepting transported diamonds, none can be expected in that quarter; *on the south*, lias limestone stretches along the outline of the counterscarp of the second range of hills—and here again (excepting the diamonds of the counterscarp) none are ever found—being perhaps buried by the overlying limestone; *on the west*, the sandstone becomes thinner, being often little more than a mere capping; the conglomerate form is also frequent, but in the diamond tract it is remarkable that there is no other conglomerate

than that which contains the diamond ; moreover, black bituminous shale rises to the surface near the village of *Sahigerh*, though in the diamond tract I have never seen it with less than 400 feet of sandstone resting upon it ; on the east, the sandstone continues pretty much the same, and I cannot offer any satisfactory reason why diamonds should not be found east of the *Cheyila Nadi*, which at present is considered to be their eastern boundary.

3d. I have endeavoured to show that the rocky matrix of the diamond of *Panna* is situated in sandstone, which I imagine to be the same as the *new red sandstone of England* ; also, that (if the transported diamonds are excepted,) there is at least 400 feet of that rock below the lowest diamond beds ; and further, that there are strong indications of coal, underlying the whole mass ; how far this may agree with the *geological position of the same description of mines in Southern India, will best be seen from the following extracts.

As far as I understand, Dr. HEYNE, in his tracts on India, pages 103-4, the hills which surround the rock mines of *Banganpilli*, are composed of slate clay, and his account of them reminds me much of *Panna*, he says, " they are straight at top, and usually level for some extent," so that even

* Mr. MAWE says, " the diamonds of *Brazil*, like those of India, are found in a loose gravel, immediately incumbent on the solid rock, and covered with vegetable mould and recent alluvial matter. This gravel consists principally of rounded quartz pebbles of various sizes, mixed with sand and oxide of iron ;" in some parts which he visited, he says further, " the gravel is cemented by means of the oxide of iron into a considerably hard conglomerate forming rocks and low hills, in the sides of which are water-courses produced by torrents during the rainy season, in these hollows, diamonds are not unfrequently discovered," and he concludes by saying, that " if this conglomerate is not the real matrix of the diamond, its true geological situation is unknown." (MAWE on Diamonds.) The matrix of Mr. MAWE appears to resemble that of the transported diamonds of the *Panna* mines, and as far as I can judge by description, it seems still nearer to resemble those of Southern India.

even villages are built on them—he says also, that “ the water of the wells is brackish,” a strong indication of their saliferous nature, and further “ that the country about *Banganpilli* is sandy and stony, and that the stones are chiefly conglomerates, composed of silicious materials.”

With respect to the rock in which the matrix of the diamond is found, his description is as follows—“ the solid rock of the hills (which by the bye is not quite destitute of diamonds,) is an aggregate, consisting chiefly of a coarse grey hornstone, with rounded pebbles of the same species, but of a fine variety of stone, or of jasper, of different colors; at some depth, this rock becomes ferruginous sandstone, the grains of which are finely cemented together, and this kind of stone usually forms the roof of the floor of the mines; the floor is generally of a reddish brown color with shining particles, and strikes fire with steel;” again he says, through this solid rock the miners must make their way before they arrive at the diamond matrix.

Dr. VOYSEY's account of these mines is “ that the diamond matrix,” in its rocky state, is “ a sandstone breccia ;” it lies under “ compact sandstone, differing in no respect from that which is found in the main range, it is composed of a beautiful mixture of red, and yellow jasper, quartz, chalcedony and hornstone, of various colours, cemented together by a quartz paste, it passes into puddingstone composed of rounded pebbles of quartz, hornstone, &c. cemented by an argillocalcareous earth, of a loose friable texture, in which the diamonds are most frequently found.”

The apparent discrepancy in these accounts is not irreconcilable—but Dr. VOYSEY is most distinct in his description, he says that the rock under which the diamond matrix is found, is compact sandstone, and that it differs in no respect from the sandstone of the main range, he did not see
the

the floor, but Dr. HEYNE appears to have done so; and, if I understand him right the floor is sandstone also, for he says, (page 105,) that the diamond bed is of the same nature with the rocks both above and below it, but is distinguished from them by its superior hardness, and that the floor is so hard that it strikes fire with steel, a peculiarity which equally applies to the *Panna* mines.—Dr. VOYSEY arrived at the following conclusions.

1st. That the matrix of the diamond in the mines of Southern India is the *sandstone breccia of the “ clay slate formation.”

2d. That those found in alluvial soil are produced from the debris of the above rock, and have been brought thither by some torrent or deluge, which alone could have transported such large masses and pebbles from the parent rock, and that no modern or traditional inundation has reached to such an extent.

3d. That the diamonds found at present in the bed of the rivers are washed down by the annual rains.

I cordially agree with Dr. VOYSEY in the general result of his conclusion, because I am satisfied that the same circumstances are applicable to the mines of *Panna*, but I nevertheless differ from him in two points; 1st, I could not trace any likelihood of diamonds being washed away by any natural causes now in operation, such as the annual rains—they are, in general, too deeply covered with soil, even in their most superficial beds

* As it appears from his description that the pebbles are rounded, perhaps the term conglomerate, or puddingstone, would be better than breccia, at least it would be more in accordance with terms already recognized.

beds to admit of this conclusion, and such only as might have accidentally laid on the surface could be so transported.* 2nd, I cannot agree with his nomenclature with regard to † “clay slate formation,” because he himself says, that in using the term clay slate, he does not mean the *Thonschieffer* of WERNER, which is the only recognizable term for that rock according to the Wernerian system, but excepting these two points, I have found great accordance with his result, and am happy in having it in my power to express it.

4th. There is another circumstance to which I must advert, but I do so with diffidence and under a hope that it will be considered merely conjectural. Dr. BREWSTER supposes the diamond to have originated like amber, perhaps from the consolidation of vegetable matter, and that it gradually acquired its crystalline form; by the influence of time and the slow action of corpuscular forces: the late Dr. VOYSEY adverted to this opinion in his account of the diamond mines of Southern India; and on the occasion of publishing an abstract of that paper in his *Journal of Science*, Dr. BREWSTER observed that he saw no reason to alter his opinion: now as the rock matrix of the diamond of *Panna* appears in some respects, though not altogether, to resemble that of *Banganpilli* in Southern India, there would seem to be little chance of my conjecture being useful, still however as every opinion regarding the origin of this fine mineral is as yet theoretical, I will not withhold what occurred to me on this subject, though I again repeat that I offer it with great diffidence.

The

* My meaning with regard to this point of difference is, that I consider the transported diamonds to have been chiefly swept away by diluvial action, and that alluvial agency must have been very inconsiderable, though I do not deny its partial influence.

† It has occurred to me on reading Dr. VOYSEY's paper on the diamond mines of Southern India, that the rock which he has termed clay slate, may, perhaps, be the slate clay of the English geologists, or the secondary argillaceous schists or shales of Dr. MACCULLOCK, which are associated with secondary sandstone; Dr. HEYNE mentions slate clay as being the chief constituent of the surrounding rocks in the *Banganpilli* mines.

The theory of Sir JAMES HALL on the consolidation of strata frequently recurred to me when examining the sandstone in which the diamond is found ; I thought that I could discern much in favour of it, and particularly in the gradual changes of its nature, from the lower to the upper strata ; now if the principle of this theory is admitted to be correct and applicable universally, it follows of course that it must be applied here ; and then it may be questioned, how the diamond was preserved, under that *degree of heat which must have been necessary to form its matrix the gritstone ? In answer to this objection I suggest, that, the circumstance of calc spar occurring in trap rocks is somewhat analogous, and if it is admitted that compression under the weight of strata, and a superincumbent ocean, had the effect of resisting the expansion of its carbonic acid and constraining it to continue in combination with lime, might not the same principle be reasonably enough applied, to account for the preservation and detention of the elements of the diamond in the gritstone ? and again, should it be further shewn that crystals, such as those with which we are familiar in nature, may be produced by slow cooling or other processes according to the above theory, may we not look to it also, to account for the crystalization of the gem ?

This conjecture rests upon the truth or fallacy of Sir JAMES HALL's theory, or, on a modification of it, and when this theory is considered as the result of long and patient experiment, and the high reputation of its author is taken into account, it will require something more than limited observation, or ordinary ability, to answer its objections ; my part, however, is merely the suggestion of a traveller, and I therefore conclude my paper by expressing a hope, that this important mineral may meet with more able investigation.

VI.

*. See the Note appended to the article of *Panna* mines, p. 106, of this volume.

VI.

ON THE

GEOLOGICAL AND MINERALOGICAL

STRUCTURE

OF THE

Hills of Sitábaldí, Nagpur, and its immediate vicinity.

BY THE LATE H. W. VOYSEY, Esq.

Assistant Surgeon His Majesty's 67th Foot.

THE hill of *Sitábaldí* although agreeing in form and interior structure with other basaltic hills in its neighbourhood, merits a more particular description on account of some peculiarities in the composition of the main rock, hitherto unnoticed by Geologists, and for the opportunities afforded by its extensive quarries of studying the varied structure of the rocks of the trap family, which is rarely to be seen in so distinct a manner.

The mass of the hill is composed of porous basalt, with a semi-columnar appearance, derived from numerous vertical fissures. It passes in some places, both in a gradual and abrupt manner into a coarse porous wacken or indurated clay, which in its turn changes in a similar manner to the nodular basalt or wacken, of which the northern and southern summits

of

of the hill are composed. At the junction of these rocks, the passage is sometimes so gradual as to give the intermediate rock an indeterminate character partaking of the nature of both. At others, it is abrupt, yet notwithstanding the abruptness of the change, the vertical and horizontal fissures are prolonged into each and cross the line of junction. I shall not here enter into a greater detail of these appearances, but shall content myself with observing that the most satisfactory explanation of these phenomena, is derived from that theory which ascribes to the trap rocks an igneous origin, under pressure of a great body of water.

The semi-columnar basalt forming the greater part of the hill is very porous, containing numerous amygdaloidal cavities, which are for the most part merely lined with a peculiar mineral, which I presume to name **conchoidal augite*; sometimes, however, they are nearly filled with it, or with calcedony, semi-opal, or carbonate of lime; the calcedony being usually covered with a coating of green earth. The rock itself is composed of hornblende and felspar, with the augite, so profusely disseminated, as to claim a right to be considered in some cases, as a constituent of the rock. This is, I believe, the first time that conchoidal augite has been found entering into the composition of basalt. The rock is fusible† and is of considerable specific gravity, notwithstanding its porosity. The vertical and horizontal fissures are not always straight, but are at times waved; they are also, sometimes lined with an infiltration of calcedony coated with clay and chlorite.

This

* From the difficulty of procuring specimens sufficiently large to analyse, I have not been able to determine its composition exactly.

† I have lately had an opportunity of fusing a large piece of the *Sittábaldi* basalt in a steel furnace; the product after an hour's fusion was a fine black opaque stone, resembling porous obsidian: glass bottles are commonly made in the Mediterranean from basalt, and that of *Sittábaldi* seems to be of an equally favourable nature for that purpose.

This rock is succeeded by an indurated clay or wacken, which at its junction with the basalt, frequently partakes of its semi-columnar structure, the vertical fissures being prolonged into the wacken, and the stiptose structure of the latter extending into the basalt: these changes may be very favorably seen in the fosse, which surrounds the fortification.

The indurated clay or wacken seems to form but a small proportion of the hill, as it is not seen in the hollow between the greater and less elevation, the semi-columnar basalt being there uncovered by any rock. It also contains crystallized carbonate of lime and semi-opal, but calcedony coated with green earth, is the most common mineral found in it.

This rock passes into the nodular wacken, which, on a casual inspection, appears to be a collection of stones rounded by attrition, and involved in a matrix of clay; when examined more carefully it is evident that this appearance is owing to a peculiar modification of the concretionary structure, developed by decomposition. Nuclei, of various sizes, are enveloped by concentric lamellæ, which peel off as decomposition destroys their cohesion. They are consequently seen in various states of decay and of sizes, varying from several feet in diameter to several inches. But their true nature is easily discovered by the mutual indentation of the different lamellæ, which surround their respective nuclei; the centres from which this pseudo crystallization has proceeded. The existence of the vertical and waved fissures, need scarcely be adduced as farther proof that they are not the product of alluvial detritus.

It appears most probable that they owe their forms to molecular magnetic attraction, since they contain a very large proportion of oxide of iron (nearly twenty-five per cent.) as may be perceived by the great specific gravity of hand specimens.

The nodular wackon or basalt, is one of the most common forms of trap in the extensive districts, composed of the rocks of this family, south of the *Nermadā*.

It occurs perpetually in the extensive and lofty range of mountains, situated between the *Pūrna* and *Taptī* rivers, and appears to form their principal mass. It is found equally abundant throughout the whole of *Berar*, part of the provinces of *Hyderabad*, *Beder*, and *Sholapur*, and appears to form the basis of the great western range of trap hills, which separate the *Konkan* from the interior of the *Dekhin*.

It is probably one of the main sources, when decomposed, of the black diluvial soil, to which *Hindsuthan* owes so much of its fertility. The valley or extended plain of *Berar*, that of *Hasanabad*, of *Seronj*, of *Nundiāla*, south of the *Krishná*, of the *Pálnád*, bordering the *Krishná*, and numerous others, all lie near the course of rivers, which at some former period have covered these plains and formed their extensive deposits of alluvium. Whether the deposition originated in some sudden and partial inundation, or whether it was owing to the gradual subsidence of the waters of the great deluge, I think may be determined by cautious investigation; I am at present inclined to think that the most probable cause was the latter.

The hill of *Sítabaldī* offers favorable opportunities, if the quarries are extended, of ascertaining positively whether the basalt is merely a superficial deposit, or is deeply connected with a mass beneath. It is surrounded on all sides by gneiss, or slaty granite, which is found at the base of the hill a few feet deep. Perhaps *Nagpur* affords more opportunities than any other part of India, of studying the geological history of these rocks, as it is situated near the junction of the primary and overlying

lying rocks. Numerous opportunities must arise during the excavation of wells and baths, of ascertaining the connexion of the strata beneath. A well in Mr. ALEX. GORDON'S garden, near the base of the hill, of about forty feet depth, penetrates through three or four feet of black soil, succeeded by a magnesian siliceous clay, which appears to owe its origin to the decomposition of the gneiss, by which it is immediately followed, and which continues to the bottom of the well.

From the summit of the hill of *Sitabaldi*, the difference in the outline of the rocks eastward is very perceptible. * The flattened summits and long flat outline with the numerous gaps of the trap hills, are exchanged for the ridgy, peaked, sharp, outline of the primary rocks. At *Ramtek* and its vicinity, the rocks are of granite and gneiss. At *Dúngarí*, at *Palora* and *Parsúni*, are found crystallized marbles passing into gneiss, capable of receiving a fine polish. Some of them contain a small quantity of carbonate of magnesia. At *Khorarí*, a dolomite or magnesian marble is found also in gneiss. At *Nayakúnd*, *Parsúni*, and the bed of the *Pesh* river, granite and gneiss of various kinds, also quartz rock and sandstone; and foliated black manganese ore is in great quantity.

* Captain BAYLEY'S plates of the Battle of *Sitabaldi*, give a very correct idea of the flat outline of the basaltic trap hills at *Nagpur*.

VII.

OBSERVATIONS

ON THE

*Geological Appearances and General Features of portions of the
Malayan Peninsula, and of the Countries lying betwixt it
and 18° North Latitude.*

BY CAPTAIN JAMES LOW,

Of the Madras Army.

IT is with extreme diffidence that I venture on this subject, as it is one which cannot be fully elucidated without a much more extensive research than I have had it in my power to make, and a higher degree of geological knowledge than I possess.

Since, however, the countries alluded to, have not hitherto been geologically described, and as political circumstances preclude British research from a wide portion of these interesting regions, the Society will, I trust, receive with indulgence the results of my personal investigation,

The grand general features of the *Indo-Chinese* regions seem to be alternate ranges of hills stretching nearly north and south, and conforming
occasionally

occasionally to the general direction of Peninsular Tracts, and of valleys of various breadth, through which flow large rivers.

The principal ranges are, that which divides *Asam* from *Ava*, then the *Siamese* and *Ava* range, next the *Siamese* and *Cambyan*, and again the *Cambojan* and *Anam* range. The continuity of these appears to be most liable to interruptions as they approach the south, and none of them, as far as my information extends, can be compared in height to the secondary ranges of those lofty *Himalayan* mountains, from which they are evidently offsets. The broadest valley seems to be that of *Ava*, and the narrowest the *Cambojan* one. The general inclination to the south of the whole of the regions lying betwixt *Bengal*, and the sea of *Skamskatka*, is apparent from the course of the rivers being in that direction. From regions contiguous to the sources of these rivers, the tide of population which overspread the southern plains, appears to have flowed, a position which might be illustrated by the affinities of languages.

The *Indo-Chinese* ranges are in so far as we yet know covered by deep forests. It is only, therefore, in the ravines, formed by torrents, and on the face of an occasional precipice, that their structure can be conjectured; and these facilities are available at but a very few points, owing to the wildness of the countries in which they occur, and of the barbarous hordes which roam over them.

I will begin with that part of the *Malayan Peninsula* lying in about 4° S. latitude, and keeping on the west coast. This point is, in the *Perak* country, which is governed by an independent Malayan chief in alliance with the British. From this last circumstance we may hope in time to gain a more perfect acquaintance with its geological peculiarities.

Close to the entrance of the *Perak* river are the *Bountin Islands*, hilly, with rocky shores. *Granite* seems to be here the prevailing rock. The plains of *Perak* are chiefly alluvial, up to the line where a marked ascent towards the central range is discernible, and which may, perhaps, be averaged at fifteen miles from the sea. The range in question is a portion of the great N. and S. one, which divides the *Malayan Peninsula* longitudinally. The rivers to the eastward of it consequently disembogue themselves into the *Gulph of Siam*, while those to the westward enter the *Bay of Bengal* and the *Malacca Straits*. This range, generally, considered, lies nearer to the west than to the east coast of the *Peninsular*. Where it bounds *Perak* on the east, it is both lofty, and, in so far as observed, continuous. Gold has been found in the beds of some of the mountain torrents which join the *Perak* river. From specimens of ores of gold, found in the hills east of *Malacca*, it would seem that the matrix is most frequently quartz. That the *Malacca Peninsula* was the golden Chersonese of the ancients, cannot now be proved, but it yields at this day gold in sufficient abundance to render this position probable. The granite formation appears to predominate amongst the *Perak* hills, and in it are found the veins of tin from which the Dutch formerly derived much profit, and which now yields valuable supplies of that metal. The mines must be very rich, since even at this period the native workman seldom digs above ten or twelve feet below the surface, and often contents himself with merely washing the soil taken from the beds of rivulets, and separating the oxyd of the metal in the shape of a black sand. The oxyd of antimony is also obtained in large quantities amongst the hills, but my specimens being pure I cannot specify the rocks with which they are associated. Lime is also (according to native formation) obtained, but its nature and locality have not been ascertained. From some native accounts also it seems not improbable that coal will be discovered in this track. *Perak* is a fine country, watered by a river of a very picturesque nature, and it contains a considerable population

population of Chinese and Malays. From *Perak*, northward to *Penang*, the coast is level, with a few detached hills, not characterized by any peculiar feature, which might contrast them with those we have been describing. *Penang*, it is well known, exhibits an almost exclusive granite formation. The granite is, for the most part, grey, and decomposable, generally flaking off by exposure. It protrudes at the summit of the hills, and may be found lining their base. Mica occurs occasionally in pretty large masses, and white quartz, regularly crystallized, is found sparingly. On the shores of several of the small islands lying off it on the south-east, conglomerate, tinged with oxyd of iron, is found as well as the usual granite.

That part of the great peninsular range in the latitude of *Penang*, is much broken; but many of the hills are of considerable height. The loftiest one, visible from *Penang*, may perhaps be stated at four thousand feet. They are almost all rich in ores of tin; and were European scientific men to be permitted to explore them, we might expect to derive interesting results from their labors. A table land of considerable elevation and covered with grass, is reported to be about north-east of *Penang*, in the centre of the great range. The jealousy shewn by the *Siamese*, has hitherto prevented me from visiting it. Marble is reported to be found in this direction; but no specimens have been obtained. The Malayan inhabitants are all friendly to the British.

That portion of the *Kedda Coast*, facing *Penang*, has evidently, in many parts, been rescued from the sea. The period when this happened is not traditionally known, although it is conjectured that it is not very remote: mounds of sea-shells are found about two miles inland. There are detached hills on this part of the coast, which contain tin.

The *Kedda Peak* (termed by the natives *Gúnong Cherai*), is an object of considerable geological, as well as geographical, interest. Its height has not been correctly ascertained. It may perhaps be stated at three thousand feet at least above the level of the sea, which washes part of its base.

The summit has not been reached, as far as I am aware, by any European, although perfectly practicable. This has been greatly owing to the jealousy of the *Siamese*. From specimens of rocks and ores brought from this hill by intelligent natives, who were sent by me to explore it, I am enabled to state with some measure of confidence, that it principally consists of the usual granite of this coast. On the sea face is a cliff washed by a waterfall, where large crystals of white quartz are got;—similar crystals were brought to me from a spot near the peak. The summit is a granite rock, with a flat termination of a few square yards bare of vegetation, and accessible with difficulty. This mountain contains gold; and tin ore was formerly obtained in large quantities on it. Various ores of iron were brought to me from it, and it is probable, that many other valuable minerals may yet be found there. This mountain abounds with all the valuable woods of this coast, amongst which are several kinds of fir. The inclination of the hill is apparently to the east, and there is a very remarkable break (of six or seven hundred feet, judging by the eye and telescope, at the distance of ten miles,) in the rock, east of the peak, which may have been caused by an earthquake.

The latter phenomenon, it may be remarked, is not followed by such violent effects on this coast, as on the *Island of Sumatra*, and on *Java*. The existence, however, of hot springs in various parts of the central range, indicates the prevalence of mineral substances, of which specimens have not yet been obtained.

Advancing northwards from *Gunong Cherai*, and passing the mouth of the *Kedda* river, which takes its rise in the central range and fertilizes an extensive track of rich soil, the first object which attracts the attention, is the elephant rock, a short distance north from *Kedda*. It is a dark mass of granite seemingly, and it shoots very abruptly out of the forests to the height, perhaps of four hundred feet.

The coast continues low to the northwards of this point. Turning to the *Laueang Islands*, we find granite still prevailing, but here in the "bird nest rocks," we are enabled to note the southern termination in this line of the limestone formation which has been traced by me up to the northern boundary of the *Martaban* province. I have no doubt, that detached lime rocks abound in the central range, but they are not connected with this formation in so far as we yet know. The first decided indication of the presence of lime, was observed in a perforated rock, lying off the N. E. side of *Pulo Trotto*.

The calcareous rock is here much tinged by oxyd of iron, and mixed up with different earthy substances. The strata are inclined to the west at an angle of about 30°.

Several miles north of this point, the *Trang* rocks begin. The first of these was visited by me; but it merits much narrower inspection, than time permitted me to make.

It is a huge mass of heterogenous rock rising out of the sea to the height of about three hundred feet. Its shape approaches to an oblong square, and it is rendered inaccessible by cliffs. The whole seems inclined at a slight angle to the south.

From the decomposing nature of the surface, it would be no easy task to arrive at a speedy conclusion respecting its whole structure. It appeared to me to rest on a granitic base, covered by various admixtures. The superincumbent mass is heterogenous. Lime stone in various stages; veins of quartz and ores of iron are most prominent; calcareous incrustations line the hollows of the cliffs; where also the agate mineral abounds;—and the cliffs are, in some places, curiously marked by broad vertical ribbon-like streaks, varying in colour according to the strata from which the water, containing the colouring matter, has flowed—white, black, and dark bluish, and slate colours, are most frequent. At the south end about half way up the cliff, there are magnificent natural arches. The grotesque calcareous stalactites, which depend just over the entrances to these, give them, as a whole, the aspect of a decayed gothic ruin.

A cavern has been formed quite through the north end of the rock by the action of the sea below, and the gradual decay of the structure above. Stalactites here abound.

Our boat carried us into the centre of this cave; it is gloomy, but the roof is perhaps fifty feet high, and dome-shaped though rugged. Here were observed flimsy ladders of flexible cane, stretched betwixt projections of the rock, and on emerging from the cavern, similar ladders were observed to have been arranged up the face of the cliff, in a zig-zag manner, here fastened to a jutting point of rock—there reeved through a perforated angle. These had been thus placed by adventurous Malays, in quest of the edible birds' nests. Their trade is more dangerous than that of the samphire gatherer, or the Hebridian Birder; but it is more profitable than either. Several of the birds' nest islands, in this line, have been so tortuously hollowed out by the slow operation of ages, that, previous to going in, the nester fastens to the entrance the end of the clew
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he takes with him, that he may not lose his way. On these occasions they use dammer torches. The eye of the swallow which builds these nests, must be peculiarly formed to enable it to work and nestle in such a labyrinth, where total darkness prevails.

A pocket compass was placed close to that part of the cliff, which seemed most strongly impregnated with iron ; but it was not affected.

Near, and to the north of this rock, is a very rocky island, termed *Ka Pesa* by the *Siamese*, because, in their legends, it is related, that an undutiful son having denied assistance to his parents, out of the profits of a successful voyage, the gods sent a storm which drove his vessel to sea, where it was transformed into this rock.

The general structure nearly corresponds with that of the rock just noticed ; but it has a most singular aspect from a series of peaks which rise from it—bleak and striated, and which, on a near approach, resemble the chimnies of glass manufactories. The geological features of this island may be best seen at the north end, where large masses have fallen from the cliffs. Here granular magnetic iron ore imbedded in a calcareous and micaceous gangue, was found in considerable quantity. A nearly similar sort of iron ore abounds on the high ground on the main land, at the entrance of the *Trang* river.

These rocky islands are adorned by numerous beautifully flowering shrubs and trees, and are frequented by the white sea pigeon (*Columbadelmaris*), and by birds of passage. A coarse coral bottom prevails around each ; but the depth suddenly increases at the distance of two or three hundred feet from the shore : oysters are abundant. At the north side of the narrow entrance to *Trang* harbour, in N. Lat. $7^{\circ} 20'$ is a remarkable calcareous

calcareous rock, with several caverns in it. The carbonate of lime, in conglomerated masses or in stalactites, is here much purer than that found amongst the islands just described. Several of the stalactitic masses are bell or fungus-shaped, the apex upwards, and when struck, are found to be remarkably sonorous. These are all tinged with iron.

Pulo Tilibon, which forms the northern side, exhibits granite and iron stone, with veins of quartz in it. From all that I have seen, it should seem that the lime formation becomes more compact and pure, as it is followed in a northern direction.

The rock in question contains a detached portion, having a stratified appearance, and inclining to the S. E. at an angle of about 35° . In one of its caves were observed twelve human skulls, laid out in a row. They were those, the Siamese said, of Burmans, who were slain in those wars, when they attacked and destroyed *Tilibon*. Part of the stockade, which surrounded the town, was yet standing, when I visited the spot in 1824, about fourteen years after its destruction. The thick planks, or beams, were quite sound, and very hard. The tree, from which these durable walls had been obtained, is the *Mai-ke-um* of the Siamese, and the *Rayú gittah* of the Malays.

The *Trang* river is broad—with a high ridge running at right angles to it, on the west side of the entrance. Granite rocks here protrude through the soil, which is red and ferruginous. The shore is overspread with lumps of micaceous iron glance very fusible. The iron is in small rounded particles—black, but yielding a reddish streak, and when reduced to powder, adhering to the magnet. The matrix is a brown ochre, which soils the fingers. The quartz, which is found imbedded in the granite of this coast, is generally very lammellar, and the plates transparent. There
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are several hills discernible from this place ; but little information was obtained regarding the great range. The young Raja of *Ligor* informed me, that the pass, betwixt the hills, is difficult ; but as he rode his elephant the whole way on several occasions, his account is no doubt exaggerated.

Most of the small islands, lying betwixt *Trang* and *Junk-ceylon*, seem, for the greatest part, composed of granite. It prevails in the latter island, and here again tin appears in proximity to, or interspersed in it, and its debris.

A range of hills, the highest of which, I believe, will not be found to exceed one thousand feet, stretches longitudinally through the island, with one large break in the middle. The island was probably once joined to the mainland, since the *Papra Strait*, which separates the two, is narrow and rocky. The island, when I visited the interior in 1824, had a population of six thousand souls (Siamese.)

The tin formation seems to run in a continuous line from the southern extremity of the Peninsula up to about 15° N. Latitude. Beyond this point neither Burmans nor Siamese have discovered any mines. But as the countries, lying on both sides of the great belt of mountains, are, perhaps to a distance of twenty miles, respectively, from the skirts of the latter, inhabited by wild tribes of *Karians*, uninterested in the search for this metal only, it is probable that tin does exist in these latitudes. It shews itself again in *Thampè*, one of the provinces of the *Shán*, as the Burmans term the inhabitants, and lying, if I can depend on the distances given to me by natives of the country, in about 20° N. Lat. and Long. 99°-100. The natives call themselves *Plau*. They are shorter in stature than the Burmans, and their features partake much of those of the Chinese.

There the tin ore occurs in beds of streams mixed with sand. The natives do not dig mines to get at it, owing perhaps to its being of little value at such a distance from the coast. They have, however, by their own accounts, valuable lead ores, which they reach by deep shafts.

In Captain FORREST's time, when *Junk-ceylon* was visited by numerous native traders, the mines yielded an average annual quantity of five hundred tons of tin. But as the population has been reduced to about six thousand souls, and as the Siamese have mines closer to their capital, a very small supply only is now taken from the island. Perhaps it may be rated at one hundred Bahars of 446 lbs. averaged each. A Chinese smelter informed me, that he could afford to produce tin at a cost of one-half at the utmost of the market rate. The miners dig pits of from twelve to twenty feet deep; but seldom venture a lateral shaft. The ore is generally in round or oblong masses, with well defined crystals, and in a matrix of quartz, or bedded in masses resembling half decomposed granite, yet of considerable hardness.

The furnace in which the pounded ore is smelted, is made of a compact of clays and earths, is oblong in shape, and about three feet high. Alternate layers of ore and charcoal are put into it, and the usual horizontal *tube bellows* of the Chinese, is kept incessantly at work during four complete days (of twenty-four hours) and one night, when the furnace is cleansed. After some hours labor, the tin makes its appearance, and is run into moulds, and the furnace is fed with more ore and fuel.

The *Bay of Phúnga*, which stretches N. E. from *Junk-ceylon*, is remarkable for the magnificent rocks, with which it is studded. At the distance of ten miles, they appear like huge artificial pyramids; but on a nearer approach, their outlines change to columnar, or massive. The principal

principal rocks occupy a line of about ten miles, in a north and south direction. The northern extremity lies behind the town and valley of *Phúnga*; the southern rests in the sea, about four miles from the mouth of the *Phúnga* river. Their direction, therefore, is nearly that of the *Trang* rocks. The part of the range, lying in the sea, consists of numerous detached rocks of different elevations, and mostly inaccessible. The height does not in any instance, I should state, exceed five hundred feet, and seldom falls short of two hundred. One of them has a very columnar aspect, which might lead a distant spectator to suppose it was basaltic. They are all, however, chiefly composed of, I suppose, primary limestone, and like the rocks which have been already described, exhibit no traces of organic remains. Some of the specimens of stalactite, which have been presented to the Society, were taken from one of a series of grottos in and near the base of one of the *Phúnga* rocks. These caverns are about six feet above high water mark. The roofs are low, and seldom exceed ten feet in height, and they look as if supported by the natural pillars of spar, which have been gradually formed by filtration from the top. Several of the stalactites have barely reached the floor—others touch the floor, and a double formation is going on. The sides of the grottos are lined with the same calcareous spar.

There is an insulated rock near this spot, which is perforated by a grand natural tunnel. To the top of the arch the height is about twenty feet, and grotesque-shaped stalactites depend from above the entrances from the roof. A boat can get within the arch.

The valley of *Phúnga* is about three miles long by one, on an average, in breadth, being oval-shaped, and widest near the sea. It is hemmed in, to east and west, by rocks and hills. Those on the west are least abrupt, and seem mostly granitic; those on the east have a very picturesque

picturesque appearance, and where the river washes their base, present perpendicular cliffs of four and five hundred feet. They are even more purely calcareous than the rocks at sea, for many look at a short distance, as if formed of chalk. This they owe to the agarie mineral. Tin abounds in the granitic hills in the vicinity of this valley. The great hill range of the Peninsula, was not observed from this point, owing to the intervening rocks. But the Siamese chief informed me, that it must be *crossed* in the route thence to the opposite coast of the Peninsula. No information could be expected from him, as to the rocks associated there. The population here is about eight thousand souls, including six hundred Chinese, and about one hundred Siamese priests of all ages.

Passing to the northward of *Junk-ceylon*, the coast is bold for the distance of a degree; and lying about thirty miles off this line, are numerous calcareous perforated rocks, frequented by the edible birds' nest gatherers.

From all accounts obtained from native travellers—from personal observation when sailing up the coast, and with reference to the narrowness of this part of the Peninsula—it has appeared to me that the great central range is here of less width than at any other point. But I cannot admit, that this circumstance, as some have imagined, should give any color to the supposition that any internal navigation is, or could be, rendered practicable betwixt the *Bay of Bengal* and the *Gulph of Siam*. I have before me native plans, in which the hills are laid down as continuous. At any rate, the inclination of the countries towards the *Gulph of Siam* on the one side, and the *Bay of Bengal* on the other, is so great as to prevent the rivers which flow over them from being navigable to good sized boats, beyond perhaps ten or twelve miles from their mouths.

The sources of two rivers may indeed lie within a few miles of each other on opposite sides of a hill or a range—yet the spot where they respectively lose the name of mountain torrents, and become navigable, may be very widely asunder. It is true, that by running up the *Kra*, or any other stream in a boat, a traveller may get within two or three days march of the place of embarkation on a river on the opposite coast: and this is all that can, with our present information, be admitted. All the rivers on this coast are wide, and some are deep at their mouths; but, with the exception of the *Tenasserim* and *Tavoy* rivers, which incline to the northward and avoid the hills, they suddenly contract and grow shallow. Tin abounds betwixt *Junk-ceylon* and *Mergui*.

The coast of *Tenasserim*, from 10° to $12^{\circ} 30'$ N. is shut out from the ocean, by high and generally rocky islands.

Those which form the west side of *Forrest's Straits*, up to the N. point of *Domel*, in $11^{\circ} 3'$ N. (instead of $11^{\circ} 21'$ as he gave it), are well wooded, and are chiefly composed of granite. *Domel* is a fine island, twenty miles in length, by twelve, or thereabouts, in breadth, with a rocky coast. On sailing past a spot, described and sketched in *Forrest's* work, and at which he mentions having taken in marble ballast, I could only find a great quantity of large smooth boulders of quartz, which had been associated with slate; for, upon inspection of the coast, thick strata of soft, black slate, with veins of quartz, were discovered. The slate had, in some places, an admixture of iron ore.

In coasting *Domel*, the hills on the mainland are distinctly perceivable. The highest point was conjectured to be about three thousand feet high. These hills belong to the great range in all probability. The highest peak of *St. Matthew's Island*, may be nearly as high.

All the islands in this chain examined, shew bold coasts towards the sea.

There is a considerable opening north of *Domel*, where a distinct archipelago of bleak and rocky islands begins, and stretching north and south. The belt is formed of four or five parallel rows of islands, and may be twenty miles in breadth. They are not laid down in the Charts. A vessel, I sailed in, passed through amongst them in coasting, and as the numerous dangerous rocks with which this hitherto unexplored track abounds, rendered it necessary to anchor frequently, I had opportunities of visiting many of the islands. The channels are, for the most part, deep, and a vessel of two or three hundred tons can scarcely find anchorage near many of the islands when within half a cable's length of them.

Their formation is primitive. The granite is occasionally associated with black shistose strata, or sandy slate. The specimen produced, was taken from a vertical stratum, of exceedingly indurated shist tinged by oxyd of iron. Lime rock was not observed to prevail. But several of the islands seem heterogeneously composed. Occasionally quartz, white and tabular, was seen to pervade in broad veins the granitic rocks.

Several "birds' nest" rocks are scattered amongst this group, and it may be inferred that they are calcareous. Pearl oysters are occasionally picked up. The pearls got from them are seldom of much value. If pearl beds of any considerable extent do exist, the practice of diving for them, as at *Ceylon*, might be applied with advantage. The whole of the islands noticed, are destitute of any fixed population. But there is a tribe, termed *Chalome* and *Pase*, the families of which rove about collecting the birds' nest, the dammer, the beche-de-mer, conch slugs, wax, scented woods,

woods, and other products of the islands. They live in covered boats, and appear inoffensive; readily bartering the above articles for such merchandize, as the *Burmans* bring to them.

The *Siamese* appear to exert very little, if any, control over these islands. Their part of the coast terminates at *Pak Chau*, a river of no consequence further than what it forms, according to *Siamese* opinion, the southern boundary of the *British* possessions in this quarter.

Leaving this coast for a space, I will now cross the Peninsula, and endeavour to give as brief an account of such geological and mineralogical notices as I have been able to obtain, respecting *Siam*.

The sea, which washes the shores of the Peninsula on the east side, is studded with numerous islands, bold, and, for the most part, rocky. The edible birds' nests being here procurable from the caves, it is probable, that lime abounds in the rocks. Along the shores of the *Chúmphan* and *Chanja* districts, ferruginous strata are prevalent, and loadstone is said to be procured from them.

At *Ban taphan nae*, nearly in the latitude of *Mergui*, are the only gold mines now worked in *Siam*. The gold is either in the shape of dust, or found in a reddish earthy matrix. To get this last kind of ore, pits of no great depth are dug. The ore is merely submitted to the agency of fire. It is not believed, that these mines yield annually more gold, than would be valued at perhaps about 15,000 rupees. But the miners (about from two to three hundred, it is understood) only mine during three months in the year, and as they go very clumsily and unskilfully to work, the real value of these mines remains unknown.

A diligent author,* who visited *Siam*, observes of the *Siamese*, that "neither their mines of tin, nor those of copper, lead, and gold, have experienced the benefits of the industry and intelligence of the *Chinese*."

Previous to opening a mine, the *Siamese* propitiate the spirits of the ground and of the stream, by the sacrifice of cattle and poultry, and by offering up these and fruits on temporary altars. This custom is equally observed by *Chinese* and *Malayan* miners, on opening gold or tin mines. With respect to the *Siamese*, the practice is a direct breach of the primary ordinance of their faith, "not to kill that which has life," and points to a period when they worshipped *Genii Loci*, and other imaginary *Dewtas*. Cornelians are found, it is said, on this coast.

Proceeding northward, till within about a days coasting of the *Siam* river, a hill, termed *K, hau Deng*, or "*the red hill*," appears on a point of land. The coast is covered with ferruginous earths and strata; but of these no specimens have been obtained. Close to this place, and stretching for the distance of ten or twelve miles northward of it, is a very remarkable range of pyramidal hills and rocks, termed by the *Siamese* "*Sam sae yat*," or "*the three hundred peaks*." They vary in height from an hundred feet to perhaps twelve hundred feet; some rise from the sea, others are scattered on the main land.

This account I give from native information, although European navigators have incidentally alluded to them. They take from hence a kind of *hone*, (perhaps *iron ore*), varying in colour from black to white. The valley of *Siam* is chiefly alluvial, within the scope of the annual inundations

inundations of its river. The first rocky formation of any consequence northward of *Bankok*, the capital, is at *Prabát*, three days by water, north-east of the old capital, and where there is a famous impression of a foot of *Buddha*. The *Siamese* priests have long imposed this sculpture on their followers, who never doubt their assertion, that the legislator alluded to stamped the impression with his own foot.

This *Prabát* has been made on the solid rock [a granite, if my information is correct], which protrudes at top; and a stair has been cut out of the rock to ascend by. A copper ore is said to be found on the flat grounds near this place. About fifteen or sixteen miles above *Prabát*, there is a low hill called *Phra Chanja*, where granite, from my information, prevails, and where the natives fancy they can trace on the face of a rock, the lineaments of *Buddha*. Iron ores are found here. At *Naphabúri*, on the south of the road to *Laos*, large quantities of a very white argillaceous earth are obtained, and red ores of sulphur are said to be brought from this quarter. At *Khorát* they use, it is said, a plum-pudding stone, or breccia, for building; and at *Naphabúri*, in this quarter, they find yellow, red, and white ores of arsenic (*Realgar?*) a metal which enters largely into the *Siamese* Pharmacopœia. The range of hills, stretching N. E. from a point in about N. Lat. 16° on the east bank of the river of *Siam*, yields ore of iron in great abundance; and the *Chinese* have, therefore, established a large party at *T'hasung*, a town lying on a branch of the river. They manufacture various coarse articles of cutlery, which are rejected by the *Siamese* themselves, in favour of foreign importations of that metal. Iron mines exist also at *Sokkothai*, higher up the river. The range of hills dividing *Siam* from *South Laos*, is continuous, according to every account I have received from native travellers, who invariably go most of the journey by land. They affirm, that there is no water communication across the country; so

that the river *Anam*, laid down by some geographers,* appears to have no existence.

The *Me Nam*, or great river of *Siam*, has been traced by me, in native maps obtained from people of *Laos*, up to about 21° N. Lat. where are high hills abounding in hot springs. *P.hokhau Lo-ang Prabang*, a hill many days to the northward of *Laochág*, in the south of *Laos*, yields, it is said, gold and precious stones. It may be the *Mohany Leng* of Du HALDE, where, he observes, were to be found "gold, silver, copper, tin, and red sulphur." At *Chantabún*, on the east coast of the *Gulph of Siam*, granite is believed to be the prevailing rock, and quartz-crystals, *Ceylon* diamond, and coarse rubies, cat's eyes, and other precious stones, are collected, it is reported, in the vicinity. Steatite is found in *Ligor*.

We now return to *Tenasserim*. The high islands fronting *Mergui* are, I think, of primitive granite; and *King's Island*, with most of the lesser islands in its neighbourhood, present bold granite cliffs to the sea.

The hill, on which the town stands, consists of granite, decomposed at the surface, with much quartz interspersed in veins. The ochery appearance of the soil, in some places, indicates the presence of iron, and tin ore is found in the streams at the base of the hill;—lead ore is reported to exist in the upper parts of this province. The rocks on the island forming the west side of the harbour, are strongly impregnated with oxyd of iron. In the vicinity of the town, argillaceous petrifications are found. The clay contains some lime. But no marks are discernible near *Mergui* of lime rocks;—some petrified crabs were obtained. The province of *Mergui*, or *Tamau*, abounds with tin ore, especially to the southward.

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* PINKERTON and others.

The sea, northward to *Tavoy*, is pretty free of islands. Gray granite is the prevailing primitive rock throughout the province of *Tavoy*.

There is a low range of hills, which stretches north and south, close along shore, and shuts from the sea a great portion of the province; nearly opposite to the town of *Tavai*, on the west bank of the river at *Kaman*, is an elevated ridge of several miles in length, which is almost wholly composed of iron stone of different degrees of compactness. On the surface, the soil and gravel are reddish. But on a high part of the ridge, is a rock very hard and fine grained, but not striated, and of a blackish colour. It is strongly impregnated with iron, and so magnetic, that a piece newly detached and of a pound in weight, held a piece of iron, nine grains in weight, in suspension. It was with much difficulty, that a few specimens could be taken off with an iron crow. This rock might, from its black appearance, be supposed of meteoric origin. But it is evidently connected with the ferruginous strata beneath, and seems not to contain any nickel.

Tavoy is a very hilly province. The first range connected with the great centre belt, lies about ten miles east from the town. Hence to the main range there is a succession of north and south ranges, gradually increasing in height, and having very narrow valleys betwixt them. Through these valleys flow rapid streams which, after pursuing the direction of the valleys to various distances, find outlets, and then turning westward flow through level tracks until they reach the sea. The route to the *Nay Dáng Pass* into *Siam*, lies about north-east from *Tavoy*. I performed the journey to the summit of the *Pass* in 1825, and on foot, as the road is impassable either to elephants or horses. Indeed the only paths, in some places, are the beds of mountain torrents. A dense jungle covers the face of the country, precluding the probability of satisfactorily pursuing

pursuing geological pursuits. The tin mines, lying three miles off the route, were visited by me. They do not here deserve that title, as the *Tavoyers* merely wash the sand of the streams, and collect the fine black particles of ore. The temperature of the air is found to be about 64° or 65° until eight or nine o'clock, and that of the water 68° (FAHRENHEIT'S thermometer), so that the workmen never begin their labour until that hour. As the population does not extend beyond the first range of hills, and the mines are buried in the forest far beyond these, the men are exposed to the attacks of elephants and other wild beasts which here abound.

Other mines of tin lie on the southern coast below *Tavoy*, and a meagre, black, and slightly sparkling ore of antimony has been obtained from the province, but its locality I am not aware of.

Frequent vertical or inclining strata of hard slate, and sandy slate, are found at intervals to lie across the path; but wherever a bold cliff appears, scarcely any thing except granite is visible.

At *Laukyen*, fifteen miles north-east from *Tavoy*, (a halting place or circular cleared space of the forest), and lying a few hundred yards on the east of the route, my guides shewed me a hot spring in the almost dry bed of a torrent.

The adjacent strata were, after many hours labor, laid bare, and specimens were taken from the spot where the water bubbled up. The rock appears to be a transition slate, passing into limestone (for it effervesces slightly with an acid), and having thin films of pyrites betwixt the cubical portions which compose it. The water raised the thermometer to 144° . The gas which escaped was not inflammable. The pebbles around were
incrusted

incrusted with a calcareous salt. The water has no peculiar taste. There is a mound on the eastward of the spring; but no volcanic indications were perceived in any direction.

The great *Tenasserim* river was crossed in this route in a track, where either perpendicular cliffs of granite, or wooded hills, hem it in on both sides. Its bed is strewn with large blocks of the same primitive rock. By leaping and stepping from one to the other of these, we crossed to the east bank. The breadth is here, as far as I can recollect, (in the absence of my notes) about thirty yards. It is quite impassable in the rainy season. From the appearance of the stream here, I should be inclined to fix its source somewhere about $15^{\circ} 30'$ north. The road, distance to the top of the *Nayé Dáng Pass*, is about sixty miles. In a direct line it is about fifty miles. It was found impossible to march early in the morning, owing to heavy dews and mist, and the whole day was often employed in getting over ten or twelve miles—so difficult was the march rendered by the necessity of crossing (often twenty times in a day) mountain torrents, and the streams they feed, and of ascending rugged beds of streams and ravines, where the guides were not unfrequently at fault. A considerable tract of table land was passed over during the route. The average temperature of FAHRENHEIT'S thermometer was at sun-rise 64° —and at mid-day 74° . But it was often 72° at the former period, and 69° or 70° at the latter.

The rocks at the pass could not be well examined, owing to the thick jungle—but the surface is evidently a decomposing granite. From this elevation, which I am not inclined to rate higher than three thousand feet, four very distinct and higher ranges of hills were seen within the *Siamese* frontier.

* The month was one of the dry ones.

frontier on the east, while the lesser ranges on the *Tavoy* side could be easily traced.

From the view here obtained, I feel disposed to allow forty miles at the least for the breadth of the whole space, in this latitude, occupied by hills. The ranges are as nearly as may be parallel to each other.

In my overland route to *Yé*, the surface was rarely found to exhibit any other than the granite formation—quartz was occasionally abundant.

At *En-bieu*, near *Kaling Aung*, on the left of the road, and in the middle of a circular level spot in the jungle, is a curious hot well. It was found to be quite marshy all around, although it was visited in the hottest period of the year. It was not without difficulty that it could be reached near enough for examination both from the heat under foot and the treacherous nature of the soil.

The well is about forty feet in diameter. By throwing a bottle attached to a rope, allowing it to fall and grow heated, and pulling it suddenly back, the temperature was found to be 94° of FAHRENHEIT. But 4° more may be allowed for accidents. Not a rock or pebble could be seen near the well. A bleak on the surface, angular, sharp and disintegrated, scraggy granitic rock lies a short distance to the northward of it.

The water has not been examined by tests. From this hot fountain down to the stockaded town of *Yé*, in the small province of that name, the country falls rapidly (to the south.) A few detached hills are perceived at intervals, and on the east of the route a low granitic range stretches northward—resting on the south at *Tavoy Point*, and to the north in *Martaban Province*.

The low hill, on which the stockaded town of *Yé* stands, exhibits no peculiar features to attract a geologist—granite decomposed at the surface, is most prevalent, I believe.

On the route from *Yé* to *Martaban*, I perceived in the dry beds of rivers massive strata of striated clay slate of a fawn colour. These strata are either vertical, or dip at a considerable angle—*Martaban* and the adjoining countries, would well reward the labors of a geologist. As the *Burman* war was being carried on, when the former was visited by me, it was not without the imminent risk of being cut off, or of being made a prisoner by the enemy, then encamped on the north side of the river, that I was enabled to explore the country up to about north latitude $18^{\circ} 20'$.

A hasty geographical sketch of this province may here be altogether irrelevant—for, without some idea of the localities of a country, the future geological traveller may find his plans prove abortive.

Martaban is bounded on the north, by a branch of the great central range of hills dividing it from *Siam*. On the south, it merges into the district of *Yé*, being divided from it by the *Balaméin*, a narrow stream. On the east, the *Siamese* range presents a very formidable barrier, shewing at intervals peaks of considerable elevation. The highest of these was conjectured to be about five thousand feet in height. Across this wall, there is only one good pass, that termed *Pra-song-chú* by the *Burmans*, and *Phra Chedu-sam-ong* by the *Siamese*, "the pass of the three Pagodas," and lying in latitude $15^{\circ} 18' 00''$ N. longitude $98^{\circ} 29' 15''$ E. according to Captain GRANT's observation after the peace. Another, but difficult pass, lies directly north of *Martaban*. On the west, it is partly bounded by the sea, and partly by the provinces of *Chetáng* and *Thám Pagú*. It may be computed to contain about twelve thousand square miles.

The principal river is the *Kráng Mautama*, (of the *Peguers*,) or *Sanlún*, (of the *Burmans*,) which rises in a range of mountains to the north-west of *Che-ang Mai* in *Laos*—passes within two or three days' march of that capital—and after a turbulent course, apparently betwixt two of the inferior ranges of the great belt, discharges itself with impetuosity on the plain just above the island of *Ka Kayet*, in about $18^{\circ} 20'$ north latitude. It is joined at the *Ka Kayet* stockade by the *Yúnzalen* river, which flows from the *Haphún* hills, lying in a north-west direction from hence; and which I believe to be the same, which I observed from the great *Shui Madú* temple at *Pegu*, to bear as follows—the northern extreme N. N. E.—southern extreme E. $\frac{1}{2}$ a point south—and about forty miles distant. But the stream was found by me to have a bar of granite across, about eight or ten miles beyond the stockade, and not to be navigable to the smallest canoes. Hence it rolls more quietly on till it disembogues itself into the sea at the *Khyet Khamí Pagoda*. Opposite to *Martaban*, it may be about a mile in width.

The other rivers which swell it are the *Dáng Damí Kyáng*, which joins it at *Mahi Phrá Pagoda*; the *Gyén Kyáng*, which falls into it at *Phrá Pyé*, or the “*White Pagoda*,” the *Attarám*, or *Attiyán* river, which enters it nearly opposite to the town of *Martaban*—the *Wahú Kyáng*, which disembogues near the *Kyét Khamí Pagoda*—and the *Dáng Wein Kyáng*, which pours itself into the *Gulph of Martaban*. These are navigable far inland by large boats.

The chief hills within the province are part of the *Tavai* range, with its branches—one of which is divided by the *Sanlún* river at *Malamén*. It runs in low broken hills, about fifty miles north of the town of *Martaban*, and joins the *Jeu Kyét* mountains—next a short range running across one of the upper branches of the *Attarám* (or *Attiyán*) river—the *Jeu Kyét*

Kyét Phra-tàng, a high peaked hill, fifteen or twenty miles to the westward of the town—the *Jogabeu-tàng* to the northward, and the two isolated hills, called *Dáng Dám* and *Majin*.

The numerous detached and insulated rocky hills which are scattered over the plains, and the many islands which surround the expanded *San-lún*, together with the dark and towering *Siamese* hills in the back ground, produce scenery of a very impressive kind.

The ranges of hills in this province betray granite as their chief ingredient. But the *detached* and very abrupt rocks and hills, of elevations of from two hundred feet to eight hundred feet, which shoot up from the plain, have in so far as examined by me, been found to be invariably composed of limestone. The limestone is in various stages, from an earthy and gritty kind up to hard marble—and the cliffs on several of them have the same marked features, which the *Trang* and *Phungá* rocks display—being streaked with red, brown, and white, and evidently suffering a rapid decomposition. The plains on which these are based, are covered generally by an alluvial soil—but in some places, it is dark and porous, like the cotton ground of India. The substratum in the lower parts is commonly a stiff clay, but towards the *Siamese* range the soil becomes more friable, tinged with oxyd of iron, or mixed with debris of rocks, and resting on gravel in large round masses. Here on the banks and on the low islands the *Khyén* tribes cultivate cotton, indigo, tobacco, and pulses. Potter's earth is obtained in abundance near *Martaban*. Of this, most of the utensils known by the name of *Paga* jars, were formerly made.

On the low range of hills, on which *Martaban* stands, granite, perhaps, predominates. But at the town, many slaty and sandy strata having an inclination of about 30° here tinged with oxyd of iron, there

intermixed with slightly calcareous and other matters, and quartz are observable. At *Mulamein*, a *breccia* is found, which has been used in the construction of the Pagoda there. This substance hardens so much by exposure, that it will last for ages, as it has here done. On the high grounds, which occasionally flank the river, the surface is tinged red by

About fifty miles by water up the *Attarum* river, and within about two miles of its eastern bank stands *Seale-ding*, one of the singular limestone rocks just alluded to. About mid-day, betwixt it and the river, and on a swampy plain, slightly inclined to the river, I was gratified by discovering a singular hot fountain (for it is of too peculiar a nature to be merely termed a spring.) The *Burmese* call it "*Ye-bu*," "hot water." The orifice is nearly a circle, the diameter of which is about thirty feet. The rim is of earth, and only raised about a foot above the surface of the water. Not having been prepared for such an interesting object, I had not provided myself with a line. But the depth is, no doubt, very considerable. The water was so clear, that the green calcareous rocks which project from the sides were quite distinct at a depth of twenty feet at least. A strong bubbling appears near the middle. A thermometer propped from a bamboo was dropped into the water, and after a space quickly withdrawn. An allowance of two degrees being made for loss of heat in the removal, the temperature by *FAHRENHEIT's* thermometer was found to be 120° , which is 12° hotter than the Bath

Had any volcanic indications been observed in the vicinity, the circular formation of this well might have induced the belief that it had once been a crater. A visitor to this place ought to approach it with caution—since part of the water near the edge is covered with weeds, which so resemble the surface of the bank, that a person might unthinkly step on them

them to his inevitable destruction. He would faint instantly from the heat and sink. Although the wells on the plains were all nearly dry at the period when this fountain was visited, yet it discharged twenty gallons on the least computation in a minute—and towards the east side. The leaves and branches which had fallen near were incrustated with a calcareous deposit—and the bottom of the rivulet was covered with a flaky calcareous substance. No specimen could be obtained of the rock, as it lies far below the surface. But from the greenish hue perceived in it, we may suppose it to partake of the nature of the specimens brought from *Lankyen* hot spring in *Taroy*. I drank some of the water, and was not afterwards sensible of any peculiar effect from it. Upon subsequently examining it with the obliging assistance of a Medical gentleman at *Martaban*, it was found to be a chalybeate, and to contain lime in combination with some other earth or earths. The tests are enumerated below. This fountain lies on the route to *Siam*, and from many coconut trees scattered about, it is evident, that though now a jungle, the plain once supported a numerous population. Near *Yé*, on the sea shore, there is a pond to which the *Burmans* ascribe marvellous virtues. It is said to grow quite red occasionally. Probably iron ores are abundant there.

Betwixt

* I was favored on this occasion with the company of Lieutenant GEORGE M. N. I., and Mr. ADAMS, of the Marine Service.

† Mr. BROWN, A. S. M. N. I.

‡ 1st. Tincture of catechu precipitates a dark brown substance—hence the of iron is inferred.

2d. It does not blacken paper,

don of lead.

3d. No precipitate is caused

ie water a solution of nitrate of silver.

4th. When mixed with a solution of turmeric, (in equal proportions,) no sensible change of colour is induced.

5th. When mixed with an equal quantity of lime water, a light, white precipitate, is formed, which does not effervesce with muriatic acid.

6th. The concretion found on the leaves and common pebbles effervesces strongly with muriatic acid, indicating the presence of lime in the water.

Between this place and *Malamein*, on the east bank of the same river, stands the very majestic lime rock *Phabaptung*, the base of which is washed by the stream. It has been perforated quite through by a rivulet. The limestone composing it takes a fine polish—and large stalactites depend from the roof of the grand arch overhead. It, like the rest of the rocks examined, shews no traces of organic remains.

In rowing up the *Sanlin*, or main river, the first objects which attracted my attention were the *Krahla-tung* rocks, being a continuation of the great lime formation. The river at one spot is hemmed in betwixt two rocks and being thus narrowed rushes through with considerable impetuosity. The rock on the north-west bank overhangs its base, the latter being washed by the river. On a sharp and one should suppose almost inaccessible pinnacle, a small Pagoda has been built, producing a pleasing effect to the eye of a distant observer.

The cliff is conjectured to be two hundred and fifty feet high. On that front facing the river, some niches have been cut in a pyramidal space, and in these stand many painted and gilt alabaster images of *Buddha*. A narrow opening leads into a magnificent cave, which has been dedicated to *Buddha*, since many large wooden and alabaster images of that deified mortal were found arranged in rows along the sides of it—the wooden images were mostly decayed, through age, and had tumbled on the floor. The rock consists of a grey and hard limestone. The cave bears no marks of having been a work of art. The *Burman* priests, who inhabit a village on the opposite bank, could not afford me any information respecting it. No inscription was discovered on the rock. It is rather a singular circumstance, that no *Bali*, or other inscriptions on stone of any antiquity, have been discovered in the *Indo-Chinese* countries—and it is the more particularly so as regards *Burma*, where the natives have

(with

(with reference to their semi-barbarous state,) attained to a very respectable degree of proficiency in sculpture. The bells of their temples have generally inscribed on them some pious sentences, and the name and titles of the person who bestowed them.

The only inscription observed by me, was that which *Alongphra*, or *Alampra*, caused to be engraved on a marble slab; which stands under a shed at the great *Shui Madu* temple at *Pegu*. It records his valorous exploits and pious disposition. The alabaster, of which the *Burmans* form their images, is only procurable within the proper *Ava* territory. The *Prapatha*, or *Prabát*, is an engraving often found on granite slabs at temples—and is intended to represent an impression of a foot of *Buddha*. They contain many emblems, most of which are obscure, and only to be made out by the help of a *Phúngí*, or priest of *Buddha*. The *Martaban Phúngis* could not inform me when *Buddhism* was introduced into *Martaban*. But from several circumstances, it should seem, that the country was only settled about A. D. 1286. From an attentive examination of such *Bali MSS.*, as have come into my possession, I am quite disposed to conclude, that the *Buddhist* religion reached the *Indo-Chinese* nations progressively from *Ceylon*—and that the *Bali* language, as now used amongst them, however varied the alphabets may be in which it is written, is identically the same with that employed by the *Cingalese* priests of *Ceylon*. This last approaches so very closely to the *Pracrit*, that it becomes doubtful which is the elder language of the two. A comparison betwixt them would shew, which is the direct derivative from the *Sanscrit*.

Above the rocks described, the river flows through a rich alluvial country, thinly inhabited by tribes of *Khyens*, or *Karians*. These people carry on a bartering trade with the traders of *Martaban*. They treated

me with as much hospitality as their situation admitted of. They are generally a fine race of people—athletic, and of much fairer complexions than the *Peguers* and *Burmans*. Their whole deportment favorably contrasts with that of these two races.

They live independently ; keep dogs for the chase ; cultivate cotton ; weave it into cloth, and dye it with the indigo raised by themselves :—and they are very comfortably housed. They change their ground every two or three years. I met a whole tribe in rapid progress down the river. They gave as a reason that the *cholera* (which seems, from time immemorial, to have prevailed in the jungly parts of these regions), had swept off so many persons, that they had been obliged to abandon their village, and seek a new abode. Opposite the small *Khyen* village of *Miehan-taung*, which lies on an island, is a singular rocky hill ; the base of which is washed by the river. It may be six hundred feet high, and it has a black and scorched appearance. It is almost bare of grass, and there are only a few trees on it. These grow in the hollows and crevices. It might be taken for basalt or granite at a short distance, but on a close inspection is found to consist of a black limestone, breaking off into cubical fragments. The ascent is abrupt and difficult, and the tread of the feet is succeeded by a hollow sound as if the hill was but one vast catacomb. Several pits, having circular orifices, and of about three feet in diameter, were observed in the ascent. They are of considerable depth, for stones thrown into them were heard for about twelve seconds, rebounding in their descent to the bottom. On looking down these, I noticed large fungus-shaped stalactitic masses hanging from the sides. Near the summit of the hill, the ridges of the rock are so angular and sharp that scarcely one of my people escaped being badly wounded in their feet.

From the top a most pleasing and extensive view was obtained of the surrounding country, and the bearings of remarkable objects were taken. On a bleak ridge, about two hundred yards from where we were, a wild sheep or goat was observed. This animal's colour is nearly black, and the hair shaggy. Several balls were fired at it without effect. The natives said, that this species was only occasionally to be met with ; but as *they* had never seen a sheep, it could not be ascertained from their accounts, whether the animal we saw was of the goat or sheep tribe. I may here observe generally, that the wild animals and birds found in the countries we have just been going over, are chiefly the following : elephants, which are very numerous ; the rhinoceros, which *Malays, Burmans, and Siamese* dread more than they do the elephant, owing to its savage temper ; the bison, which is found of a very large size in *Thedda*, the head being of a fawn colour ; the wild ox, of the size of a large buffalo ; and also a species, resembling in every respect the domestic ox ; the buffalo ; the royal tiger ; the leopard ; bears (but very rarely seen), tiger-cats, about the size of a fox ; leopard-cats, having very beautiful coats, and being about the size of the common cat, but more slimly formed ; the fox-cat, with tiger stripes, and which is destructive to poultry—this animal lives in dens, but it climbs trees in search of prey.

The elk and various kinds of deer, are abundant. Baboons, asses, sloths, opossums, flying and other squirrels, chameleons, and other varieties of the lizzard tribe, various species of the tortoise, alligators, and guanans, are very numerous. In *Tavoy*, the natives keep packs of large dogs, with which they run down deer. These dogs run by sight, and they are regularly kennelled. The breed seems peculiar. I observed a dog at a remote village in that province, equal in size to a Newfoundland dog.

Wolves,

Wolves, or wild dogs, (for I had no opportunity of judging which), are found in the forests. No jackals, or common foxes, have yet been discovered, and, it is believed, that they do not exist below the latitude of 19° north. Many kinds of tortoises, as before observed, and river turtle, were seen by me. The natives, especially the *Karians*, train dogs to search for them, as they form often a chief article of their food.

The birds are :—White sea eagles, white land eagles, hawks, of several species, vultures, and kites.

The peafowl here exhibits a brilliancy of plumage, which far excels that of the *Indian* one. It is also a larger bird. There are, at the least, four elegant varieties of the pheasant tribe ; also, quails in abundance ; and several kinds of partridges, of which the green, with a red tuft, and the blue, are most conspicuous. There is, likewise, a jungle cock, having a rich blue and reddish plumage, and nearly twice the size of the common jungle fowl. He is well armed with two long spurs on each leg. Pelicans, and the usual tropical water-fowl, abound. A perfect species of duck, having a blackish back and whitish breast, and the weight of which is nearly double that of the common duck, is very common.

Leaving the *Michan-tang*, and proceeding up the *Sanlín* river, the low rocks, observed on the banks, exhibit coarse black limestone. The high cliffs further removed, shew the more advanced stage of the lime formation. At *Ka Kayet* stockade, close to the hills, the granite again begins ; and here were found scattered about smooth quartz and other pebbles of several pounds in weight, which had been used after their ammunition had failed by the *Burman* garrison when defending themselves from the attacks of the *Siamese* ;—baskets, full of these pebbles, were arranged

arranged along the palisade inside. Several specimens of regularly crystalized quartz were here picked up.

The "*Khyen Ni*," or "*Red Karen*," who inhabit the jungly and hilly tract, stretching from this place in a northerly direction, are of a very savage and warlike disposition. They use thick buffalo-hide for armour, and fight with spears and poisoned arrows. The climate of this province is temperate. At *Martaban*, during the rainy season, which is not the coldest, the following average was taken from a series of notes on the state of the thermometer:—

Average of Fahr. Ther.

Fifteen days in May,	78	82
Twenty-five days in June,	72	73
Forty-two days, from 1st July to 14th August,	77	80

The geology of Ava is little known, nor has any one of the many, who accompanied the troops up the *Irawadi*, favored the world with a connected sketch of the rocks observed on its banks. That the lime formation will be found to extend up to *Asam*, there is every reason to believe from the accounts received, and since it is known, that carbonate of lime in shape of the finest marble, and also alabaster, in a pure state, are very common in the country—thus countenancing the position taken up in another part of this paper, that the lime formation gradually becomes more compact and pure, as it bends to the north. Dr. HAMILTON observes, that "at *Prin* he saw part of the chain of hills which forms the northern boundary of *Pegu*, and that there sandstone and limestone were observed in flags. In *Thamipe*, a *Shan* district, they have lead, iron, tin—some silver it is said, and limestone.

From all that has been here stated, it should seem, that granite forms the basis of all the continuous ranges of hills on the coasts I have described;—that a bold and marked lime formation runs parallel to these ranges, but that this is occasionally interrupted, as far as can be judged of from an examination merely of the surface—that schist is of very frequent occurrence, and that tin, in shape of an oxyd, and invariably associated with the granitic hills, or formed in their vicinity (and supposed to extend up to N. Lat. 20° if not beyond it) and iron, in various states of combination, are the *principal* metals throughout this wide range.

I have only now, in conclusion, to express a hope that this rapid and very imperfect geological outline may, at some future period, be filled up by a more able hand than mine.

DESCRIPTION

OF THE

NORTH WEST COAL DISTRICT,

Stretching along the River Damodar, from the neighbourhood of Jeria or Juriagerh, to below Sanampur, in the Pergunnah of Sheargerh, forming a line of about sixty-five miles.

BY THE LATE MR. JONES,

Of Calcutta.

THE face of this country is regularly undulated by short broken swells, resembling a chopping sea: the perpendicular height of many of the hills, which I have levelled, averages about sixty feet. The soil is not more than six feet deep, slightly calcareous, resting on grey sandstone that effervesces with acids, and in many places, where it is bare an efflorescence of soda may be scraped off. The sandstone is not more than seven feet thick on the table hills, but generally thicker and coarser grained in the valleys. The coal and coal metal bassets out in many places, but are delusive guides to the miner, as the greater part of them

are

are the saddle strata that cover the hills like a cap, and seldom reach down to their bases : others again lie like shields or patches on the side of the hills, and extend a considerable depth below the bases. Beneath all these the proper coal beds will be found. The formation appears to me, from the result of many experiments, to be wavy and wheeling in a slight degree, carrying its line of bearing to an amazing extent with little variation ; its breadth on the south-west side in the direction of *Bankora*, is not more than eleven or twelve miles from the river, further on in that direction the protruding rocks are sienite, hornblende, quartz, and masses of mica or talc, cemented with a small portion of sand. At *Bajkol*, seven miles above the confluence of the *Damoda* and *Baracan* rivers, the attendants on coal are lost, and the river is blocked up with gneiss, felspar, and granite. The coal district then turns off, crossing *Jeria* in the direction of *Bahar* : coal bassets appear a considerable way beyond. The attendants on coal also appear in the *Baracan* river, regularly downwards on the *Birbhúm* side, without any interruption, except a large whyndyke that appears seven miles above *Madgeah*, running in the direction of *Bishenpur*. The whole of the district affords rich and valuable iron ore of various kinds, but no limestone has yet been discovered, except the calcareous concretions that are found on the surface of the ground, and such as are in general use as a substitute for limestone all over *Bengal*.

Description of the works at Raniganj, with the different occurrences that took place during the sinking of the three shafts.

Previous to opening the works at the above place, I made small sinkings down to the clay slate or coal-metal in the valleys in every direction within three or four miles. I found them invariably dip E. by S. which threw the line of bearing to the back of the *Raymahal* hills, considerably

considerably inland. There being little chance of finding coal long on the line of dip within reach, (and it soon bassets or crops out on the line of rise), I thought it proper to begin at this place, as I never saw the coal dip any other way, but with the regular strata that cover it. The *Rajmahal* hills are composed of mountain whin or basalt of an amazing thickness; at one place at *Moti Jharna*, a section or slip may be seen of sixty or seventy feet in height, and quite perpendicular: these hills rest on red-streaked ferruginous sandstone, of a very hard nature, such as is often the floor of coal, but I believe very seldom the roof—this circumstance favored my opinion, that the line of bearing crossed *Birbhūm* in that direction, and on the 1st December 1815, I began the first shaft. Having made my arrangements with the workmen, the sinking went on regularly, but I was much astonished to find as I went down, that the strata gradually wheeled from E. by S. towards the N. W. and when the coal was found in shaft No. 1, it dipped N. W. which continued regular in every season and bed downwards, the dip of the upper strata forming a spinal line on the side of the shaft. The rainy monsoon having now commenced, and the workmen not attending regularly, I began sinking the shaft No. 3, and cutting platforms round both shafts to the level of high water in the river, with open adits to make the approach easy. When the coal was found in No. 3, it was within two inches of the same level as No. 1, and dipping due south, I thought this might be caused by a sudden wave or ridge in the strata, or I might be working on the edge of a very small basin—this created much perplexity. I again tried the country round with the former result, and was then in hopes, that I had got on the pivot or point where the strata wheeled, which would throw the line of bearing towards *Katwa*. To get more information, I opened the shaft No. 2, and although this was four hundred and eighty feet from No. 3, on the line of dip, coal was found in the same level, dipping N. N. W., which gives, in the three

shafts, a difference of level of only two inches—and a line of dip and of bearing in each different, but the strata the same. Every appearance indicated lower beds of coal, than any yet cut through, and I continued sinking in shaft No. 1, in hopes of finding the low main, with some difficulty in keeping the water under, from not being able to keep the men at work by night on account of the bears and tigers, until I found the last stone bank suddenly change its declination from half an inch to the foot, to an angle of 45° . This great dip would make it appear a primary formation, although, I am inclined to think, it is merely, what is termed amongst miners, a trouble, occasioned by the wheeling of the strata; I, therefore, did not sink farther, as the coal is always fouled by these occurrences. I am now preparing to work the nine feet bed, from the six inch band, that covers the nine inch seam of coal, up to about six feet with an arched roof, leaving three feet of coal above the arch, the three inches of clay slate that intervene will prevent the water of the eight feet bed from dripping down, and the feeders, of the seam or bed in work, will descend below the springing of the arch, and leave the roof tolerably dry. When the mine has been worked in this manner to a certain extent, the nine inch seam and three feet bed, can be readily wrought, leaving the six inches and two inches bands on the floor, as waste or dead; but if the mine is continued in work for any length of time, it would be prudent to carry the waste up, and leave the floor clean. The coal of all these three beds, is of an excellent quality; its cleanliness renders it peculiarly adapted for culinary purposes;—it resembles the *Sunderland* coal in every respect, but leaves more cinders and ashes.

An account of the Strata met with in sinking the Colliery at

Ránúganj, December, 1815.

ft. in.

Yellowish clay, mixed, in some places, with soft black concrete
pebbles,

6 1

Grey

	ft. in.
Grey sandstone, slightly calcareous,	5 0
Yellow soft clay slate,	3 0
Clay slate, rather sandy, with a mixture of mineral charcoal,	1 0
Very hard, bluish, streaked, and gritty slate,	7 0
Tesselated band of grey basalt, dipping to the S. E. two inches to the foot,	1 2
Coarse grained, very hard and gritty slate, bluish grey colour,	3 6
Very hard stone band, grey tessalated basalt, dipping S. E. one inch to the foot,	1 10
Very hard, bluish, streaked slate, as before,	7 0
Blackish clay slate, with faint impressions of vegetables, and small bits of pure coal in many parts,	6 8
Black clay slate, without impressions of vegetables,	2 9
Black soft muddy clay,	0 4
Coal No. 1, slaty and dirty,	1 3
Clay slate,	0 2
Coal No. 2, better than No. 1,	0 4
Coal metal, or hard shale,	0 2
Coal No. 3, pretty good,	1 3
Coal metal, or hard black shale,	0 7
Coal No. 4, pretty good,	8 0
Coal metal, or shale,	0 3
Coal No. 5, very good,	9 0
Argillaceous stone band with impressions of flowers,	0 6
Coal No. 6, better than any of the above,	0 9
Argillaceous stone, with impressions of flowers,	0 2
Coal No. 7, better than the last,	3 0
Black hard shale,	2 1
Sandstone band,	0 5

Hard

	ft.	in.
Hard black shale, with impressions of vegetables,	1	3
Coal No. 8, bad, and full of gold coloured pyrites,	1	1
Tessalated claystone, with impressions of vegetables,	2	4
Grey sandstone band,	0	2
Shale, with impressions of vegetables,	0	5
Grey sandstone band,	0	4
Shale, with impressions of vegetables,	0	3
Grey sandstone,	2	0
Conglomerate bank of sandstone, clay slate, and other matter mixed in a confuse and mottled manner,	3	7
Bank of hard, sharp, gritty, greystone, with cutters, and the dip declining more than in any of the top strata,	3	6
		<hr/>
Total, feet	88	2

Retrospect of occurrences, and opinions formed thereon, while searching for Coal in Bengal.

The N. W. coal district exhibits a considerable degree of confusion, increasing as you proceed upwards, and is admirably adapted for the use of an indolent race of people, as coal, sufficiently good for common purposes, is within the reach of every body. Knowing that dislocation of strata, always occasions the coal to be foul and dirty, I opened the works in a situation where I expected to be most free from it, but the plan of the works will shew, that I was not quite successful, although I have ascertained a most valuable point; viz. the wheeling of the strata in the most desirable direction that could be wished, crossing the great line of navigation somewhere about *Katwa*, where I have not the least reason to doubt, that coal will be found, and the advantages that will result, must be

be abundant. Taking into consideration the various occurrences in the N. W. and N. E. quarters of *Bengal*, I am induced to think that the coal formation of both countries joins under the delta of *Bengal*, and that the alluvial deposit is of no great thickness; the dip of all the coal seams on the N. E. frontier, favors this opinion, and it is not improbable that this great line of coal enters *China*. From the *Garrow* hills into *Cachar*, I am satisfied of its continuation, as I discovered coal and its attendants the whole way, and found a piece of coal imbedded in a slate rock in *Cachar*. The best informed people of *Manipur*, assured me of their having traced it into the *Burma* country, but they do not use it in *Manipur* for any purpose; it is called by them, “*amúbalang*.” I am inclined to think, this coal district marks the easiest and best road into *China*. The *Surma* river is navigable for small boats into *Manipur*, but the people on this frontier are averse to travellers proceeding into their country, and when they have power, resist it.

One of the principal advantages which I anticipate from the introduction of a cheap and plentiful supply of coals into *Calcutta*, is the being able to burn lime with it, at a moderate expense. At *Sylhet*, the whole of the lime is burned with wood—an article that has of late become both scarce and dear, so that they are now obliged to depend on a foreign country, *Cachar*, for their fuel; and for which, large sums are annually sent out of our country. But in the event of the limestone being brought to *Calcutta*, and then burned with coal—that article could be had fresh and much superior to the lime as now brought, which has been burnt at least, perhaps, a year before. Besides the saving in quality, from the freshness of the lime—the deterioration sustained by the lime getting wet in crossing the great rivers, and the boats taking in salt-water in the *Sunderbans*, will be obviated, and the expense of carriage would be less, from the boats requiring no roof, and from the insurance being less—the

goods being of little value, and subject to no detriment from being wet.

The *Shergerh* district abounds in iron ores; and I find that immense quantities can be procured there at very little expense, and from the experiment I have made, I have no doubt, but extensive forges might be wrought in that district advantageously. Of other ores—there is lead in the neighbourhood of *Lakshmipur*, in the *Bhagalpur* zillah, and I have reason to suppose, copper may be found in *Dholbhúm*, near *Rajwáha*, in a stream called *Guru Nadi*, that empties itself into the *Subanrekha*.

IX.

EXAMINATION AND ANALYSIS OF SOME SPECIMENS OF IRON ORE, FROM BURDWAN.

By H. PIDDINGTON, Esq.

IN the following Analysis of Iron Ores from Burdwan, much care has been taken to ascertain correctly the presence and quantity of Phosphate of Iron and Manganese,* which two substances principally affect the qualities of the Iron when smelted; the process was conducted in the humid way, and the separation of the Manganese was obtained by Mr. Faraday's method—digestion of the Oxides in a solution of muriate of Ammonia with sugar.

No. 1.
BETWEEN JAMDE AND SUKHRAJ.
Sp. Gr. 3143.

Blowpipe—acquires a metallic tarnish and a shaggy, porous appearance, becomes magnetic: with borax or charcoal, fuses into a dark and
dirty

* Oxide of Manganese.

dirty green glass. The blue laminæ burn with the scintillation peculiar to iron, become porous, and have a metallic tarnish ; they appear to be a deut-oxide of iron.

When calcined, the pulverised ore, which is of a yellow brown, changes to a deep chocolate red ; probably from the privation of the carbonic acid.

CONSTITUENTS.

Water and Carbonic Acid, ....	.....	8	50
Silex, ....	.....	4	00
Alumine, ....	.....	4	75
Carbonate of Lime, ....	.....	5	15
Deut-oxide of Iron, ....	.....	76	00—55 Iron.
Oxide Manganese, ....	.....	1	55
		99	95

NOTE.

This specimen probably contains from 58 to 60 per Cent. of Iron, for the portion analysed was found, by digestion in nitric acid, to acquire 8 per Cent. in weight, probably from the peroxidation of the blue laminæ.

No. 2.

NO LABEL WITH THIS SPECIMEN.

SP. GR. 3081.

Blowpipe—becomes magnetic with a metallic tarnish, fuses with borax into a clear bottle-green glass.

CONSTITUENTS.

Water, ....	.....	5	75
Silex, ....	.....	3	20
Alumine, ....	.....	0	40
Lime, with a trace Mag. ....	.....	1	00
Oxide Manganese, ....	.....	4	00
Peroxide Iron, ....	.....	85	30—5950 Iron.
		99	65

NOTE.

I refer this specimen to scaly red Iron Ore, or Iron Froth of Jameson, Vol. III. p. 208.

No. 3.

NO LABEL WITH THIS SPECIMEN.

Sp. Gr. 3400

Blowpipe—becomes magnetic, and fuses with borax into a very dark and somewhat dirty green glass.

CONSTITUENTS.

Water,	6	25
Silex,	8	50
Alumine,	0	50
Lime Phosphate Iron,	Traces.	
Oxide Manganese,	0	0
Peroxide Iron,	84	50—59 Iron.
	<hr/>	<hr/>
	99	50

NOTE.

Ochry-red Iron Ore, or red Ochre of Jameson, Vol. III. p. 210. (?)

No. 4.

MAL CHAITI.

Sp. Gr. 3111.

Blowpipe—becomes magnetic, and acquires the metallic tarnish: with borax on charcoal, fuses into a pitchy slag.

CONSTITUENTS.

Water,	6	0
Silex,	4	50
Alumine, ..	1	75
Carbonate of Lime,	3	35
Oxide of Manganese (red)	16	00*
Peroxide of Iron, ..	68	00—47 5 Iron.
	<hr/>	<hr/>
	99	60

NOTE.

The large proportion of Manganese in this specimen is remarkable, but the process used for obtaining it leaves no doubt as to its identity, for the solution of muriate of Ammonia will not dissolve oxide of Iron. It may be found useful to mix with other ores, which may thus afford better Steel than they otherwise would. See Jameson, Vol. III. p. 232.

SPECIMENS OF IRON ORE.

No. 5.

PAOLTA KANOWA.

SP. GR. 3587.

Blowpipe—Scintillates, becomes magnetic, and acquires the metallic lustre; with borax on charcoal, fuses with slight ebullition into a very opaque green glass.

CONSTITUENTS.

Water, ....	....	....	.....	7	0	
Silex, ....	....	....	.....	7	90	
Alumine, ..	....	....	.....	0	60	
Lime, ....	....	....	.....	0	00	
Phosphate,	....	....	.....		Trace.	
Manganese,	....	....	.....	10	25	
Peroxide Iron,	....	....	.....	74	00	—51 5 Iron.
					<hr/>	
				99	75	

No. 6.

NO LABEL WITH THIS SPECIMEN.

Sp. Gr. 2857.

Blowpipe—becomes magnetic, and externally of a metallic lustre; with borax on charcoal, a dark enamel.

The pulverised ore, like No. 1, is of a pale yellow brown, changing to a deep chocolate red in calcination.

CONSTITUENTS.

Water and Carbonic Acid, ....	.....	9	50	
Silex, ....	.....	27	50	
Alumine, ..	.....	1	50	
Oxide Manganese, ..	.....	9	00	
Deut-oxide Iron, ..	.....	51	00	—37 Iron.
		<hr/>		
		98	50	

NOTE.

Like No. 1, this specimen acquires weight (about $8\frac{1}{2}$ per Cent.) by digestion in N. Acid: it is certainly too poor an ore to be smelted, unless under very favourable circumstances, but trials might be made of its effect on the qualities of iron produced from mixtures of it with other ores; there seems to be ground for supposing that Silica sometimes combines with Iron in the metallic state.

No. 7.

DESER GERH.

SP. GR. 3645.

Blowpipe—becomes magnetic, and assumes the metallic tarnish ; with borax on charcoal, a dark coloured enamel studded with bright gold spots, resembling aventurine : the fragments translucent and of a bright golden green.

CONSTITUENTS.

Water,	6	0
Silex,	3	75
Lime,	0	50
Alumine, ..	0	50
Phosphate Iron,	0	90
Oxide Manganese, ..	1	50
Peroxide Iron,	86	00—60 Iron.
	<hr/>	<hr/>
	99	15

NOTE.

The very beautiful appearance produced by the blowpipe, may probably be owing to the conversion of Phosphate of Iron into Phosphuret of Iron, by the combustion of the charcoal support.

The process used in the foregoing analysis differs from those indicated by the books ; I have therefore subjoined a memorandum of it for the satisfaction of the scientific chemist.

1.—Weigh the pulverised ore at the temperature of the atmosphere, and calcine at a low red heat, the loss indicates the water, and if there is change of colour (from yellow to deep red brown) probably of carbonic acid.

2.—For 100 grains of the ore take $1\frac{1}{2}$ oz. muriatic acid, boil it gently over a lamp in a covered vessel for twenty minutes, add four ounces of water, and boil again for a few minutes ; this dissolves every thing except

except the silica, alumina,* phosphuret of iron (if any exists), sulphate and phosphate of lime: filter and wash the residuum perfectly, and calcine it: its weight is that of the silica and alumina—it may be tested for phosphate and sulphate of lime, if necessary.

3.—To separate the alumina, boil on the residuum sulphuric acid, diluted with thrice its weight of water, this will dissolve the whole of it, and leave the silex untouched.

4.—Evaporate the muriatic solution at a gentle heat; when nearly dry, pour upon it about half a pint of well boiled distilled water, transfer the whole to a jar or flask, and keep it closely stopped for twenty-four hours: if any precipitate forms, it is phosphate of iron, which may be separated as usual.

5.—Drop sulphuric acid into the solution, the lime, if any, will precipitate as a sulphate; separate it and calcine at a low red heat, and by the scale of equivalents, the quantity of carbonate of lime may be known.

6.—Precipitate the solution by one of caustic soda; filter, wash, calcine, and weigh the residuum, which consists of the mingled oxides of iron and manganese.

7.—Digest these in nitric acid, with a gentle heat, allow it to remain exposed to the air till nearly dry, calcine again at a red heat, stirring it often, and weigh it; if any increase of weight has taken place, oxygen has been absorbed, and this must be allowed for in the results.

8.—To

* None could be detected in repeated trials.

8.—To separate the oxides of manganese and iron, boil them in a solution of muriate of ammonia, with a little sugar, the whole of the manganese will be dissolved, and the iron left, (it has been ascertained by independent experiment, that no oxide of iron is taken up, and prussiate of potass will satisfy the chemist that it is manganese): precipitate the manganese by water of ammonia cautiously added, and filter; if the liquid has any colour, a portion of the oxide has been re-dissolved by the excess of ammonia, and will precipitate on allowing it to evaporate; when the liquor is perfectly limpid, the whole has been obtained, and may be collected as usual:—This is Mr. Faraday's process for their separation.

X.

ON A

NEW SPECIES OF BUCEROS.

BY MR. HODGSON.

ORDER Insectores. Tribe Conirostres. Family Buceridæ. Genus Buceros.
Species New; Buceros Nipálensis: Dhanésa, Ind.

This remarkable and very large species, which I have the advantage of contemplating at leisure in a live specimen, measures from the point of one wing to that of the other, four feet five inches; and from the tip of the beak to the extremity of the tail, three feet six inches, whereof the beak is eight inches, and the tail, one foot five inches. Its body, in size, exceeds that of the largest raven, and is lank and uncompact, having a rather long and very flexible neck, slightly ruffed, a bill and tail of extreme length, high-shouldered powerful wings, and short strong legs. The colour may, in general terms, be said to be black, with a white-pointed tail, and white patch on the wings: the figure, upon the whole, and in the bird's most accustomed attitudes, clumsy and heavy.

Let

Let me now attempt a more particular description; beginning with the specific dimensions, which are as follows :

	Feet. Inch.
Wing to wing,	4 5
Beak to tail,	3 6
Tail,	1 5
Bill, length of,	0 8
Ditto, depth or height of,	0 3½
Legs,	0 10
Whereof, thighs to the knee,	0 5
Tarsi, to ball of foot,	0 2½
Central toe and claw,	0 2¼

The skinned carcase measures, from first to last joint of neck, eight inches: from last joint of neck to end of rump, nine inches.

The *bill*, which is large even for this genus, is nearly straight from the gape to the tip, but still having, upon the whole, a slight incurvation, which is most sensible along the ridge of the upper mandible, and especially towards the base of it where the arch is conspicuous, but without any abruptness. The substance of the bill is perfectly hard and apparently solid, not “cellular,” or “hollow,”* unless in a manner traceable only by dissection, which I do not pretend to affirm or deny. The lateral compression is great, so great as to render the edges above and below somewhat sharp, to destroy almost the convexity of the sides, and to leave hardly any breadth to the bill, except at the base, where it is a little thickened, but still much less broad than high. The upper mandible is strengthened by six large prominent ribs, running obliquely down nearly the

* The words thus indicated as quotations, refer to the generic character.

the whole breadth of it, and extending lengthwise from the base beyond the centre. These ribs present their prominence edgewise to the surface of the bill, giving it there an undulatory form: elsewhere, the surface is perfectly smooth. The inner margins of the bill are, by nature, united and entire, but with their edges cut out, and interlocked towards the base; and so they continue to be in the oldest birds. Towards the tip, the inner margins are, in old birds, much and irregularly broken, and separated by hard use; and the ridge also is broken by similar means.

That the inner margins of the bill are not naturally "serrated" in this species, at least, I am enabled confidently to say, from having a well-grown young bird, with a perfect bill before me.

The upper mandible of this species is not furnished with an accessory member, in this respect agreeing with the Senegal Gingala and crimson Hornbills. Both mandibles are nearly equal, and tend to a point, which is obtuse, especially in old birds.

The base of the culmen, as far down on either side as the nostrils, is feathered: the remainder of the base of the bill entirely naked.

The *tongue* is very small, triangular and flat. The *nostrils* are small, rounded, basal, placed high on the sides of the bill, and covered with recumbent feathers.

The *region of the eyes* is naked, except over the brows, as far forward as the nostrils, where the skin is feathered. The *eye lashes* are strong, flattish, and tend outwards, with their tips incurved. The *legs* are short, very stout, and unfit for walking: the *tarsi* very short; in front, a little feathered at top, elsewhere shielded by a succession of single, strong, transverse

transverse scales: the *toes* disposed three before and one behind, of moderate length, dilated, flat, strong, scaly, very imperfectly separated; the anterior outer toe being united to the central one, beyond the second joint, and the anterior inner toe, beyond the first joint. This imperfect fissure of the toes, joined to their extreme flatness beneath, gives to the soles of the feet a singular character: and the legs are so placed in the body, that the bird, in perching, grasps somewhat obliquely: *claws*, arched, compressed, truncated.

The *tail* is greatly elongated; cunei form; erigible; consisting of ten unequal feathers. The *wings* are high-shouldered; powerful; of moderate length; inclining to round; the first and second quills not being so long as those that follow, and these again, not much longer than the succeeding ones. The naked skin round the eyes and base of the bill is of velvety softness, and runs connectedly from the eyes to the edges of the bill next the throat; and where it terminates below, or at the junction of the lower mandible and of the throat, is a large angular space void of horn, from the edges of which depends a bag, as large as a domestic fowl's egg, of smooth naked skin. This bag the bird fills and empties at will; but never changes its colour, as the Abyssinian Hornbill (which is also provided with a similar appendage) is said to do.

The feathers of the head, neck, and body beneath, are of a remarkable texture and substance. These plumes (if plumes they can be called) are somewhat elongated, and have long discomposed webs, and both shafts and webs are of a wiry or hairy substance. Those of the head and neck, which are rather longer than the rest, form a sort of pendant ruff, that is capable of partial erection at the bird's pleasure. This ruff has the advantageous effect of taking off from the monstrous disproportion between

the huge bill and comparatively small head and neck : but, on the other hand, its erection—from the scanty set, and separated web, of the feathers—exposes the coarse nasty skin of the neck. The rump is, I think, considerably more hardened and flattened beneath than that of other birds ; and the reason of this peculiarity, and of the shortened tarsi, would seem to be to allow the bird to rest its weight upon the rump and tarsi : for the vast size of the bill probably disturbs the equilibrium, and will not permit this bird to perch at ease, as other birds do, with legs straightened and resting on the feet.

The colour of the plumage has already been stated in a summary way. It is fitting, however, to be more particular on that head. The discomposed wiry feathers of the head, neck, and body beneath, are perfect black : the remainder of the plumage, or that of the entire back, wings and tail (with the exceptions to be immediately noted,) also black, but reflecting, with the aid of a strong light, a deep blue^g gloss, and sometimes, but seldomer, a deep green one. The third, fourth, fifth, sixth and seventh quills of the wings, for about three inches from their points upwards, are pure white ; and so, likewise, is the terminal third and more of the tail. The naked skin round the eyes and base of the bill is of a rich light blue : the bag depending from the throat, bright scarlet. Of the eyes, the irides are red, the pupils black. The bill is white, with a greenish yellow tinge, and the ribs of the upper mandible black. The feet are dark brown, approaching to black. The figure of the bird is infinitely various in various attitudes. The familiar posture is a squat, with the neck feathers ruffled out, the neck retracted within the high shoulders of the wings, and the tail frequently erected like a magpie's, at other times dropped ; and in this attitude the bird has a very stupid and clumsy appearance. When it raises itself on its feet, puts its neck
partially

partially forth, closes its neck-plumes, and drops its tail, the outline of the body is long, narrow, and not unpleasing. But to see this bird to advantage, mark him when dressing his plumage with the fine shoulders of the wings projected, the strong, nervous legs exposed to view, and the flexible neck extended and arched backwards. His figure has then some of the graces, and even terrors of the nobler birds of prey. Its disposition is placid and tranquil; but it is not therefore deficient in spirit, and when a captive and caged, though it hates, it fears not the approach of dogs, and to man's approach is quite indifferent. It is easily tamed, both from its confidence and quiet habits. Its habits are sedentary: it dislikes strong light and heat—and tenants the deep woods, covering the hills which overhang the great Saul forest. Its more peculiar haunts are the largest trees, especially such as are decaying, the trunks of which it perforates from the side, making its abode within upon the solid wood, and having its mansion further secreted by an ingeniously contrived door: so that it is difficultly found, and more difficultly taken. That which is now before me was extracted from the tree by cutting down to its nest with axes. I am told it pairs, and is not gregarious. It cannot walk, but advances on foot forwards and sideways, by hops, like a crow, or magpie. Its flight is horizontal and heavy, with neck retracted and tail dropped. The voice of the mature bird is usually a short, hoarse croak; but when angry, or alarmed, it utters a cry not unlike a dog's bark. If left alone, it seldom speaks, but when once excited to utterance, is most pertinaciously noisy.

To ascertain the habits, in respect to food, of a very rare and shy bird, is extremely difficult. After much enquiry, I gather that this species of *Buceros* feeds chiefly upon fruits—but, when urged by hunger, does not refrain from various kinds of reptiles; judging by the structure

ture of its bill, legs, and claws, (the bill is far less formidable than it seems to be, and the claws are very obtuse), one should conclude that it is not raptorial, even in the meanest sense : and its perfect freedom from all offensive odour, as well as the excellency of its flesh, (which is much esteemed by the mountaineers for the table) seem to go far towards proving, that it is almost exclusively frugivorous. Nevertheless, it cannot be denied that, in the tame state, this species will eat meat (either raw or dressed) with as much apparent relish as fruit : and its natural habits, in regard to food, must, therefore, for the present, remain doubtful. That which I am describing, is fed principally with boiled rice, mixed with ghee, and made up into large balls. Water it never touches. The throat is very wide, and the swallowing powers prodigious. Whatever is offered to the bird as food, is gulped entire, after being rubbed, more or less, according to the exigency, between the huge mandibles of the bill : and if not capable of being thus disposed of, it is rejected. As a consequence of this mode of feeding, the bird is apt to be incommoded by its food, after it has reached the upper stomach ; in which case the substance swallowed, is immediately and easily regorged into the bill, rubbed a little more, and swallowed again.

Its odious voice, awkward gait, frequently erected tail, and sombre-pied plumage, proclaim its relationship to the *Corvidæ* of the *Stirps Corvina* : whilst its superior size, huge bill, gressorial feet, and tiny, triangular flat tongue, are *family* features that cannot be mistaken.

M. le Vaillant complains of the unnecessary multiplication of species in this genus. Yet I venture to anticipate, that the bird now described, will be allowed to be a new species. I am not sure whether it be male or female : nor can I satisfactorily learn, if the sexes are distinguished by
any

any diversity of appearance. But so far as my informants can be trusted, it may be presumed that the bird, above described, is a male, and that the female bears a general resemblance to the young bird; which I now proceed to describe.

With the parent bird, a young one was likewise taken. When brought to the Residency, in the beginning of August last, it answered to the following description, and was then tolerably well-grown, and well-fledged. Wiry feathers of the head, neck, and body beneath, dingy red: tail entirely white, save at either extremity, where there was a margin of black: iris of the eye, greenish white: bill unribbed on the upper mandible, and with the green tinge stronger than in the old bird's bill: inner edges of the bill quite smooth and united: naked skin round the eyes and base of the bill and bag beneath the chin, wanting the fine colours of maturity: voice like the clucking of a brood-hen, falling now and then into the shriller, but homophonous note of the guinea-fowl: in other respects, like the mature bird. Now, in the middle of November, the changes noted below, have taken place: the bill less green, and more like the mature bird's; the first rib of the upper mandible developed: the naked skin at the base of the bill and the bag beneath the chin, taking rapidly the fine hues of maturity: the basal third and more of the tail, black; and the tip no longer black: the dingy red of the body beneath, darkened a good deal on the thighs and vent: the voice hoarser and like the mature bird's: the inner margins of the bill, still perfectly entire.

The above particulars, how tedious soever, are yet worthy of record in regard to a new and very rare species of bird. The old bird has recently died: and the young will, probably, not long survive him. Should it do so, we shall, perhaps, be thus enabled to settle the question

of male and female, and, at all events, may note the changes which the species undergoes in the progress to maturity.

It is proper for me to conclude with remarking, that having no extensive or scientific knowledge of Ornithology, I have been obliged to rely for the materials of the above description upon untutored eyes and ears, sedulously employed and assisted by careful reference to Shaw's Zoology.

XI.

ON SOME

PETRIFIED SHELLS,

FOUND IN THE

GAWILGERH RANGE OF HILLS,

IN APRIL, 1823.

BY THE LATE H. W. VOYSEY, Esq.

Assistant Surgeon His Majesty's 67th Foot.

THIS remarkable range of hills is called, by Arrowsmith, in his last map, the *Bindeh*, or *Bindachull* (*Vindhya* or *Vindhyāchala*) hills. The same name is, however, given to a lofty range of hills on the left bank of the *Godaveri*, as it passes through *Gondwana*, and also to those near *Gualior*. I shall, therefore, distinguish them by the name of the *Gawilgerh* range, particularly as, after repeated enquiries, I have never been able to discover that they were so designated either by the inhabitants of those hills or of the neighbouring plains. They take their rise at the confluence of the *Purna* and *Tapti* rivers, and running nearly E. and by N. terminate at a short distance beyond the sources of the *Tapti* and *Warda*. To the southward, they are bounded by the valley of *Berar*, and to the north, by the course of the *Tapti*. The length of the range is about one hundred and sixty English miles, and average breadth, from twenty to twenty-five miles.

On

On the southward side they rise abruptly from the extensive plain of *Berar*, the average height of which is one thousand feet above the level of the sea, and tower above it to the height of two and three thousand feet. The descent to the bed of the *Tapti* is equally rapid, although the northern is less elevated than the southern side of the range. The outline of the land is generally flat, but much broken by ravines and by groupes of flattened summits, and isolated conoidal frustra. The summits and the flat land are generally remarkably destitute of trees, but thickly covered by long grass. In the ravines and passes of the mountains, the forest is very thick, and, in many places, almost impervious. The inhabitants are principally *Goands*, whose language, manners, and customs differ remarkably from those of the Hindus. At present, their chief occupation is hunting and cultivating small patches of land, which produce a coarse rice and millet. In former years, the cultivation must have been very extensive, since there are the ruins of numerous hill-forts and villages, which derived their chief subsistence from the surrounding lands.

Many opportunities are afforded of studying the nature of this mountainous range in the numerous ravines, torrents, and precipitous descents, which abound in every part. A Wernerian would not hesitate in pronouncing them to be of the "newest floetz-trap formation," a Huttonian would call them overlying rocks, and a modern Geologist would pronounce, that they owed their origin to sub-marine volcanoes.

I shall not give them any other name, than the general one of trap-rocks; but proceed to describe them, and state with diffidence the inferences which, I think, obviously present themselves on an attentive study of their phenomena.

1st. The principal part of the whole range is formed of compact basalt, very much resembling that of the Giant's Causeway. It is found columnar in many places, and at Gawilgerh, it appears stratified—the summits of several ravines presenting a continued stratum of many thousand yards in length.

2dly. The basalt frequently and suddenly changes into a wacken, of all degrees of induration, and, I may say, of every variety of composition usually found among trap-rock ;

3dly. Into a rock which may be named indifferently, nodular-wacken or nodular-basalt, composed of nuclei of basalt, usually of great specific gravity, surrounded by concentric layers of a loose earthy mass, resembling wacken, but without cohesion, which, on a superficial view, conveys to the mind the idea of a fluid mass of earth, having, in its descent from some higher spot, involved in its course all the rounded masses it encountered, and, subsequently, become consolidated by drying. A very slight inspection is sufficient to detect the true cause of this appearance, which is owing to the facilities of decomposition of the outer crust, depending on difference of structure and composition. In none of the conglomerates, or pudding stones, do we observe any traces of this structure, and as it is common to the most crystalline green-stone, porphyritic green-stone, and those rocks usually denominated syenite, there can be little doubt that it is owing to the developement of a peculiar concretionary structure by decomposition. In a small ravine, near the village of *Sálminda*, two thousand feet above the sea, I saw basalt of a perfectly columnar structure, closely connected with a columnar mass formed of concentric lamellæ, enclosing a heavy and hard nucleus. Near this ravine, I had also an opportunity of observing the gradual and perfect passage of the columnar basalt into that which has

been called stratified, from the parallelism of its planes; the composition being identical, and, without doubt, cotemporaneous. These changes and passages, from one rock into the other, are so frequent and various, as to render it impossible to refer the most of them to either of the rocks I have abovementioned, as types. I shall, therefore, proceed to describe those which are distinctly marked, and their accompanying minerals. In external appearance, the columnar and semi-columnar basalt closely resembles that of the Giant's Causeway, possessing the same fracture, internal dark colour, and external brown crust. It is equally compact and sonorous. It, however contains, more frequently, crystals of olivine, of basaltic hornblende, and of carbonate of lime. The fusibility of each is the same. Perhaps the basalt of Gawilger range, more nearly resembles, in every respect, that of the *Ponce* mountain in the *Mauritius*. This is, however, of very little importance, since every body who has travelled much in trap countries, knows well what great changes in composition and structure occur even in continuous masses. Among the minerals, calcedony, and the different species of zeolite, are rarely found in the columnar basalt, but they are of frequent occurrence in that which is semi-columnar. The wacken, or indurated clay, is as various in character and composition, as the basalt, and, unfortunately, I have no type with which to compare it, as in the case of the basalt of the Giant's Causeway. Its colour varies with its constituents, but is most usually gray. It is easily frangible, very frequently friable, and is almost always porous and amygdaloidal. It appears to be composed of earthy felspar and hornblende, with a considerable proportion of oxide of iron. It is always easily fusible into a black scoria, or glass, according to the quantity of zeolite which it contains: of all the trap-rocks, it abounds the most in simple minerals: They are—Quartz.

Calcedony and calcedonic agates, enclosing crystals of carbonate of lime.

Common and semi-opal.

Heliotrope.

Plasma, or translucent heliotrope.

Stilbite.

Analcime.

Natrolite.

Ichthyophthalmite.

Felspar.

Carbonate of lime and green earth.

I have never been able to discover in it either augite or hornblende in distinct crystals. When the surface of the land is strewed with these minerals, it is a certain indication, that the rock beneath is wacken. With regard to the situation of this rock, I have rarely seen it on the summits of hills, but much more frequently at their bases, and forming the flat, elevated plains. I shall have occasion to advert to this rock again, when I proceed to describe the petrified shells.

The nodular basalt is, perhaps, the most common form of trap in this mountain range, as well as in other parts of India. It more commonly forms the surface than either of the rocks, and is as frequently seen on the summits, as it is at the bases of the mountains. It rarely abounds in minerals of any kind. It is the principal source of the rich, black diluvian soil of India, commonly called black cotton soil. I have little to add to the former description of it. Its external structure is sometimes beautifully developed by decomposition, since, in a mass of about six inches diameter, it is possible to count above twelve concentric layers, and on striking the nucleus a slight blow with a hammer, one or two more layers are broken off. It is owing to this facility of decomposition, that the annual rains carry down such vast quantities of alluvial soil from its surface, which is, moreover, always strewed with an abundance of nuclei

in

in various stages of decomposition. It is owing to the difficulty with which the roots of trees penetrate the rock, that they are so rare on its surface, and never grow to any size; yet this circumstance does not prevent the *Andropogon contortum* and *nardus* from growing in the most luxuriant manner, which sufficiently proves the fertility of the soil.

On ascending from the *Tapti*, I observed in a nullah, a group of basaltic columns, one of which was two feet in diameter, and six sided. When near the summit of the flat table land of *Jillan*, I entered on a pass, formed on one side by a perpendicular section of the rock, from twenty-five to thirty feet, and on the other, by a rapid descent of forty or fifty. The lower part of the section, as well as the pathway, is composed of the wacken, or indurated clay, of the kind I have before mentioned, of about ten feet in thickness; lying on it is a stratum of earthy clay, of different degrees of induration and purity, twenty yards in length, and of about two feet in thickness, containing great numbers of entire and broken shells. This possesses all the characters of a stratum, since the horizontal fissures are parallel, and are prolonged, with a few interruptions, through the whole extent. The accompanying sketch will serve to give a tolerably correct idea of the mode in which the stratum appears to overlie the lower rock, and to have been depressed by that which is superincumbent. The upper rock consists of about fifteen feet in thickness of the nodular basalt, or wacken. The nuclei being of all sizes. The vertical fissures, which are so remarkable in trap rocks, are prolonged from both the upper and lower rocks into the shelly stratum, although there is no intermixture of substance.

The stratum is composed of a highly indurated clay, fusible before the blowpipe into a fine black glass, and neither it nor the shells it contains, effervesce in acids. The shells are, for the most part, flattened, and belong
either

either to the genus *conus* or *voluta*. It is not possible to conceive that so fragile a substance as a thin land shell, should have been so completely flattened without fracture, unless it had been previously softened by some mode, which at the same time produced a sufficient degree of pressure to effect its flattening.

I have attempted, in the annexed sketch, to give a representation of the degree of flattening; but I fear that it can only be well understood by the specimens themselves. Neither the rock nor its contained shells, effervesce in acids. Westward, the ground is covered by the debris of a shelly conglomerate, much more indurated and impregnated with green earth, exhibiting cavities and shells in relief: from the shape of the former, there can be no doubt of their having once contained shells. Some of the shells are entire, but are greatly flattened. The matrix appears to be siliceous, and, in some cases, approached to imperfect heliotrope. It is not fusible before the blowpipe.

I may here mention that, in a report by the Marquis of Hastings, in June, 1819, I mentioned the existence of shells in trap rocks at *Maldonado*, at a height of two thousand feet above the sea. The hill was composed of nodular trap, and lying on its surface, were numerous pieces of siliceous stone, containing shells of the *unio* and *Cyclostoma*. The specific gravity of the stone varied from 2.0 to 2.5: the shells did not effervesce in acids, although some of them preserved their external polish. Internally, some of the stones appeared to pass into flint, particularly those of small specific gravity, whilst their external surface effervesced in acids. Some of the small shells were completely changed into *calcedony*. Specimens of these shells are lodged with the Asiatic Society.

It is a remarkable fact, that the only remains of animals hitherto discovered in India, should be found in trap rocks, and under quite peculiar circumstances. 1st. They are found in situations where there are no indications of the former existence of lakes. 2d. Both the shells and matrix are destitute of carbonic acid. 3d. The former are, in many instances, squeezed flat without fracture, and, in some cases, completely commixing with their matrix.

These effects could only have been produced by the agency of heat, and, consequently, the modern theory of sub-marine or sub-aqueous volcanoes, will best serve to explain the phenomena. These shells were deposited in the stratum of clay in which they are now found, and when forced up by the mass of wacken beneath, they were, most probably, at the same time covered by the nodular basalt. Thus we have heat, to drive off the carbonic acid and soften the shells under a pressure, which assisted the process, and, at the same time, flattened them.

I have too numerous collateral proofs of the intrusion of the trap rocks in this district, amongst the gneiss, to allow me to doubt of their volcanic origin. I shall take an early opportunity of completing the history of the trap rocks of India, for which I have collected materials for several years past.

XII

AN ACCOUNT OF SOME MINERALS, COLLECTED AT NAGPUR AND ITS VICINITY,

With Remarks on the Geology, &c. of that part of the Country.

By CAPTAIN F. JENKINS.

NAGPUR, the capital of the Mahratta Sovereign of Berar, is in Lat. $21^{\circ} 10'$, Long. $79^{\circ} 14'$, of Arrowsmith. It is situated on the bank, and nearly at the source of the insignificant stream, the *Nág Nadi*, from which it has been considered to take its name; but so small a rivulet might be supposed to have been nameless when the founders first began the town.

The *Nág Nadi* often ceases, in the dry weather, to have a running stream; and, indeed, that it is now a stream at all almost entirely depends on the large tank of *Telinker*, formed by a mound across a small valley in the trap hills, about three miles above the town. These hills have few or no springs, and the tank is supplied with the water collected from the adjoining eminences during the rains.

The

The *Nag Nadi*, after a short course of twenty or twenty-five miles, is lost in the much larger stream of the *Kanhan*, coming from the *Deo-gerh* Hills, and the united stream falls into the *Wyn Ganga*, at about the above distance from their junction.

The principal source of the *Wyn Ganga* rises south-east of *Seoni*, and after making a circle round the town on the south, proceeds in a northerly direction, till it is finally turned south by a range of hills beyond *Chappara*, under which village it passes through a narrow gap between basaltic columns, an impetuous, but a beautiful and considerable stream.

The *Wyn Ganga*, after its junction with the *Warda*, near *Chanda*, takes the name of *Pranah*, and the joint stream is one of the most considerable feeders of the *Godavari*. The elevation of *Nagpur*, is about one thousand feet at _____, the temperature of its climate is generally equable throughout the year, and the seasons regular.

The site of the town of *Nagpur* is very unfavourable: its want of water in the dry season, the sterility and heat of the adjoining bare trap hills at the same period, and the superabundance of water and rottenness of the soil in the wet season would seem to indicate, that it could only have been selected in connection with some sanctity attached to the hill of *Sitalgudi*, at the foot of which it is situated.

Geologically viewed, its site is, however, interesting, for it is the point of junction of the great western trap formation with a great granitic formation,

* Attempts were made some years ago to float timbers from the vicinity of *Nagpur* down the *Godavari* to the sea, with partial success, owing to the many rapids in the river; but there are no obstructions of any consequence, and which might not be removed at a very trifling expence.

formation, the extent of which is yet but partially determined. I should conceive, however, that it formed a part of the same granitic range, which is found on the confines of the plains of Bengal, reaching from the Ganges below Patna to the sea at Ganjam, and a continuation of the great ranges of the Coast, and not merely a supposed continuation below the surface, but probably traceable above ground throughout this vast extent.

The broken and disintegrated state of the granitic rocks, which come in contact with, or approach very near to the trap, afford other interesting points that may be confirmatory of the origin now pretty generally ascribed to that formation.

The hill of *Sitábalá*, the extreme eastern point of the trap formation, would appear to be insulated from the range of hills to the west of it, or its connection is by a narrow neck, for the sinking of wells, round the base of the hill has shown it to be nearly, if not entirely surrounded by gneiss.

The gneiss at its base is much decomposed, and of a greater elevation than the next adjoining uncovered gneiss in the city, which is, however, extremely shattered, and the whole bears the appearance of having been upheaved and disturbed by the basalt.

The trap hills to the westward have, in the dry weather, the most barren and uninviting appearance; being nearly destitute of water, there is scarcely a blade of grass or a shrub on them, and their whole surface is entirely covered with loose boulders of wacken balls of small size; if the rains, however, are abundant, they afford a scanty crop of stunted Jowarree. The country S. and E. of Nagpur, some distance, being the black soil of the trap, bears a tolerable crop of the same poor grain, and there is

little other cultivation except towards the Northern hills, on a reddish soil which grows a small quantity of wheat and oil crops, but mostly very thin and stunted, compared with the same productions of our provinces on the Ganges.* About Nagpur, and perhaps generally over the whole neighbourhood to which my specimens belong, the calcareous concretions which we name Kankars, are every where abundant, the nodules about Kámtí, (the cantonments of the Nagpur force,) are mostly very small, black, and hard, but burnt with charcoal, they give a clean white lime, and a strong and quick setting cement, and are more commonly used than lime from any descriptions of lime-stone, of which there are many varieties at short distances.

The soil at Kámtí is so full of small Kankar pebbles, that it is difficult to make good bricks of it; for if not kept a little underburnt, the bricks burst to pieces on being touched with water.

Within the range of my proposed sketch, there are no mines that I am aware of; but there are ores of iron, manganese, and lead, and small quantities of gold sand. The iron ores are poor, but that metal is abundantly supplied from the rich ores beyond the Nerbuddah. The manganese is the black oxide, rich and abundant, and of lead, there is a small quantity in the state of Galena, found only in detached boulders about the hills at Níma; no vein has yet apparently been discovered.

The principal and almost sole demand for quarried stone was confined, at the time I write of, to the wants of the European residents, and to the public buildings for the troops. The quarries open were, a quarry of the

* Beyond the Wyn Ganga, in the Bandara district, the principal crop is rice, and very abundant.

the basalt, at the foot of the hill of *Sitábalđi*, of gneiss in the city, (the stone used by the natives in small quantities,) the disintegrated rock, for gravelling the roads, and one quarry of sand-stone at Silwara, and another at Kámtí. A slab of marble was occasionally cut out for images at Korár, and a part of the same rock was sometimes burnt for fine whitewash; and with these exceptions, I do not remember any of the mineral productions of Nagpur being converted to use.

SITABALDI SPECIMENS.

The specimens marked No. 1* are from the quarries west of the hill of *Sitábalđi*: the basalt is here exposed the whole height of the hill, and presents the appearance of strata by the alternation of compact and porous basalt. The compact rock forming strata eight or ten feet, and the porous basalt of one, or one and a half foot thick.

No. 2 (A) All these specimens are from perpendicular fissures in the basalt. The fissures are from one-eighth of an inch to two or three inches in width, extending irregularly from the top to the bottom of the hill, and the basalt adjoining the fissures is commonly coated with a thin layer of opal, as in one of the specimens, No. 1

No. 3 (B) The eastern side and part of the top of the hill is covered with wacken boulders, those on the surface being small; but some exposed

* Basalt, compact and porous.

"The rock of *Sitábalđi* is a composition of porous Basalt passing into Amygdaloid and Nodular Wacken."—DR. VOYSEY.

(A) Calcedony—Calcedony and Rock Crystals—Calcedony, coated with green earth—Calc. Spar, in thin layers.

(B) Boulders of Wacken.

near the Resident's house, by cutting a road on the slope of the hill, are three and four feet in diameter, consisting of concentric layers of about an inch in thickness.

The specimens No. 4, (C) are from the bottom of a large well, on the slope of the hill, but near its base, in the Residency compound. These specimens were met with in an attempt to sink the well deeper, it then being, perhaps, from thirty to forty feet; the upper part of the rock had been wacken and basalt, but on reaching this rock the well-diggers were stopt, they could not get through it either by cutting or blasting, from the extreme state of induration and toughness of the rock.

On the northern side of the hill, in sinking a well, the first twenty or thirty feet were of this decomposed rock No. 5 (D); below was gneiss, more or less decayed. The gneiss was no where to be traced on the surface, and immediately north, beyond a little hollow of about one hundred or one hundred and fifty yards, was a rising swell connected with the trap hills, and which, to the extent of the depth of numerous wells sunk on it, was composed of wacken, chiefly nodular, soft and light coloured at top, but increasing in density and darkness of colour as the depth increased. This swell, or tongue of trap, runs down to the city, and as far as the colour showed, it appeared to have been situated on trap only; but a quarry in the centre of the town discovered gneiss almost immediately under the surface. The upper layer of decayed and decaying gneiss was carted in considerable quantities for repairs of roads; the under strata were much broken into cubic masses of small size, as if greatly disturbed by some most powerful agent. This stone was commonly used in the city for
rough

(C) Hornblende Schist, and Mica Schist, or Gneiss.

(D) Decomposed Gneiss.

rough buildings, and the basement of the Palace, formed of the fine basalt of *Sítábaláí*, neatly chisselled and very well put together, is surmounted by an upper story of this poor gneiss. The unfinished wall of the city is entirely of dressed basalt, at least externally dressed, and of the best execution. Beyond the ridge of trap above noticed, at a very short distance north, the decayed gneiss is again met with and quarried for the roads; but, in proceeding further north, deep trap soil covers all vestiges of rock, until we reach the granite of *Waragaon* and *Súradé*.

To the West, N. W. and S. W. trap entirely prevails; to the N. E., E., and S. E., black soil in the immediate neighbourhood, prevents the observation of the underlying stratum; but there is little doubt of its being gneiss, as this is the nearest rock displayed in those directions.

KHORARI AND WARAGAON SPECIMENS.

Nos. 1 and 2 (A) These specimens are from the hill of dolomite at *Khorári*, distant from *Sítábaláí* about six miles, and to the north of it. The intermediate country is deep, black, trap soil.

To the east is a low range of granite hills at *Waragaon*, the granite is remarkable for the great quantity of felspar in it—from its having no mica, (or a very small quantity,) and the quartz being chiefly disposed in masses and exhibiting frequently large cavities lined with fine crystals of quartz. To the west, *Khorári* is bounded by the trap range, turning

(A) Dolomite, large grained and very hard.

Fine-grained and friable Dolomites.

Dolomites with disseminated Steatite—with Tremolite, specks of Mica and veins of Calcedony.

Varieties named by Dr. Voysey, "Dolomite with disseminated Steatite and specks of Mica."

"Dolomite with veins of Calcedony."

turning off from *Sitábaldí* to the north-west and some small insulated hills of trap are scattered over the plain towards *Khorári*.

Below the dolomite hill and adjoining to it, are the coloured fine-grained dolomites, and the specimens 3 and 4, are in connection with these. To the west and north, round the base of the hill, are the konkars, (B) large quantities of which are dug up for lime. Some of these specimens are internally crystallized.

The large-grained dolomite is quarried, but not extensively, for marble blocks, and for lime for white-wash; the blocks may be cut out to almost any size. Immediately about the hill at *Khorári*, there are no other than lime-stone rocks in masses, but a vast variety of scattered pieces of stone, as gneiss, granite, quartz, &c.

KAMTI.

To the westward of the granite hills, and in line with them at a short distance, on a rising swell, Colonel ADAMS formed the cantonments of the Bengal troops on the banks of the river *Kanhán*.* Opposite, and immediately on the bank, facing the greater part of the cantonments, was the sand-stone No. 1,† described by Dr. VOYSEY, as a sand-stone with an argillaceous cement and specks of mica. The sand-stone had, apparently, a dip south towards the cantonments, under the river, but none was to be traced

(B) They cover a space about two hundred yards square, in a continued mass, and to a considerable depth, "pure Carbonate of lime."—Dr. VOYSEY.

* The *Kanhán* rises in the *Deogherh* hills, running thence nearly south, till it reaches the plain, and then turns nearly due east, and falls into the Wyn Ganga, near Bandara.

† Some varieties of this sand-stone, Dr. V. described as "sand-stone with well disseminated iron glance, one specimen resembling siliceous schist."

At the base of the sand-stone, in the river bed, were some extensive beds of calcareous conglomerate, which burned into a dirty lime.

traced on the south side of the narrow stream, its breadth inland, on the northern side, was inconsiderable, as far as could be traced. This sandstone was much broken in all directions, and the fissures, horizontal and vertical, were entirely filled with seams of lime about half an inch to an inch in thickness. The western extremity of this sandstone runs under the *Kanhán*, at a bend a little above the village of *Kámti*, forming a low fall on the river, and was here covered by "earthy red iron ore,"* of great density on the surface.

No. 2 (C) These specimens of reddish granite, or granite passing into gneiss, are from wells in the centre of cantonments ; they appeared to be only thin strata or veins, as, after breaking through twelve or fourteen feet, with very great difficulty, sand was met with underneath.

No. 3 (D) The bluish-green coloured specimens, composed principally of actinolite, were from a well almost adjoining, not more than two hundred and fifty feet distant, all the rock of which was tinged blue. Nos. 4 and 5 (E) are specimens from a well further west.

Due south of the well, which contained the specimens No. 2, about two hundred yards in some low ground, in opening an excavation for a tank, decayed gneiss was found close under the surface, and to the extent to which the tank was then excavated : the specimens No. 6, were called by Dr. VOYSEY, " granite passing into gneiss, well defined gneiss, quartz rock, red felspar, and green stone, the primitive trap of Werner." F.

In

* Dr. VOYSEY.

(C) Red Granites.

(D) Bluish Granites.

(E) Granites principally composed of reddish felspar.

(F) All specimens from a well at the east of cantonments.

In none of the other wells of cantonments, I believe, was solid rock met with, but large quantities of loose stones of every variety. quartz, granite, and green-stone being the prevailing sorts, and sand was invariably found mixed with and below the pebbles, which would almost lead one to suppose that the specimens, 2, 3, and 4, came from immense boulders, and some large white quartz boulders on the west of the cantonments, would each of them have nearly filled the diameter of the small wells. Nor was any rock visible along the river bank, cropping out to show whether the granite was continuous. Except at the extreme left of the cantonments, and distant from the wells three miles, where a ridge of red, brittle, well-defined gneiss, vertically disposed, is seen in the river bed, and lost in the right bank of the river.

This accumulation of sand and pebbles, and cropping out of the granite, gneiss, and sand-stone, causes a swell scarcely extending beyond the limits of cantonments, and afforded to the Bengal force there at the time, the advantage of well-drained hard ground during the rains; whilst that between cantonments and *Nagpur*, and all round *Nagpur* was impassable, from the rottenness of the deep black soil. An equal advantage accrued from the nature of the soil, during the hot weather, water being found plentifully at little depth, throughout the cantonments, below the sand, whilst at *Nagpur*, every hot season, nearly all the wells run dry, being seemingly mere reservoirs of water, in the basalt rock, which overflow in the rains, being filled by drainage of the surface.

SILWARA.

North of *Khorári* about two miles, on rather elevated ground, are extensive quarries of sand-stone, No. 1.* The strata are very regular, though
of

* No. 1. "Argillaceous Sand-stone of various colors."—VOYSEY.

of unequal thickness, and dip from 30° to 35° to the south. Between *Silwara* and *Pátan Sangi*, the sand-stone rises into a low hill, upon the surface of which are quantities of the conglomerate, No. 2†. This lies also in considerable masses in the bed of the stream, near *Sawner*, and appears to cover an extensive part of the country, beyond the pass of *Kelode*, on the road to *Sindwara*.

RAMTEK.

Proceeding to the north from *Kámti*, on the high road to *Rámték*, no rock is found on the surface from the former village to the slight elevation extending from *Sátak* to *Nagardan*.

About half-way, however, in a deep well, dug for the convenience of travellers, at the depth of about thirty feet from the surface, was found a granite decomposed, consisting almost entirely of pure milk-white felspar, with very small quantities of white quartz and white mica. On being taken up, the specimens of this rock fell to pieces. Not far from this, in a nullah, were found some large boulders of translucent white quartz, interspersed throughout with long thin prisms of schorl, regularly radiating from centres.

The swell at *Sátak* and *Nagardan* (No. 1.) is of quartz, but the rock does not appear in any considerable mass.

Hence, for four or five miles to *Rámték*, the road passes over deep black soil to the small advanced hill, covered throughout with quartz pebbles.

† No. 2. Conglomerate.

pebbles. This hill is in contact with the hill of *Rámték*; that is to say, the sloping sides of each meet before the valley between them falls to the level of the surrounding plain, and on the slope of the greater hill, the gneiss begins to appear immediately. This gneiss is of various colours, although the texture is nearly uniform. The specimen exhibits the prevailing rock : Dr. VOYSEY called it " gneiss, with the aspect of a rock formed by mechanical deposition."

The abrupt-peaked termination of the hill on which stand the temples, is about five hundred feet above the plain. The ascent on this side, from the village, is by a broad, steep flight of well-laid gneiss steps, with resting places and seats at intervals : the whole is of the best construction, and promises to last as long as the hill itself.

The view from the top of the hill amply repays the labour of ascent. Southward it extends to *Kámtí*, over a tolerably cultivated, open plain, but which, when the crops are gathered, has a barren enough appearance, for the intermediate villages are small and few, and for want of water, scarcely anything of what may be called the garden crop of the more favored parts of the country, is to be seen. Immediately around the hill of *Rámték*, however, are numerous large tanks, which supply irrigation to a number of *Pán Khéts*, and a few gardens of common vegetables, throughout the year. The ground near the foot of the hills is covered with mangoe trees, which extend a considerable way up their slopes, on what looks as barren a soil as can well be imagined. To the north, across a small valley of two miles or less, which is always green, and well studded with clumps of trees and villages, rises the first range of the hills which extend to the *Nermaddá*.

The prospect in this direction is very limited, and shows only hills of little elevation, entirely covered with deep jungle. To the east and west, below the range of hills, the country enjoys considerable means of irrigation, and is comparatively well cultivated. And directly underneath, to the east, is the very picturesque valley of the hill itself, which from the point of the enclosure of the temples, forks out into two branches, that, after a range of three or four miles, curve towards each other, and, though not exactly meeting, appear to do so; small detached hills and promontories enclosing the scene. At the head of this valley a large tank has been dammed in, round which are several pretty little Hindu buildings.

To this tank also, from the top of the hill, descends another noble and easy flight of steps, formed, as the other, of gneiss.

The first range of hills, north of *Rámték*, is of quartz, and the beginning of the *Ghát* is of the white quartz of the specimen No. 2; farther on, gneiss occurs, and at *Dongertál*, eleven miles from *Rámték*, and the top of the ascent, the little hills of rock scattered about the tank and valley, are of granite.

Below the hill, on the south and west, are considerable beds of marle, capable of being burned into tolerable lime.

Between the lesser *Rámték* hill, and the point of a range of quartz rock, on the west, is a gap of about two miles; and three or four miles north of this is the village of *Kumári*, the last to be met in approaching the jungle, which here is very high and thick.

On entering the jungle, the surface rock appears to be white mica schist, entirely disintegrated; and proceeding on three or four miles, the
ridges

ridges of rocks, from which the specimens from *Kumári* are taken, are met with.

The specimens of red lime-stone, Nos. * constituted the principal mass of the rocks which appeared to have an east and west direction, and to be vertically disposed; for, though there was no distinct appearance of stratification, the rocks were divided from each other, and lay in sharp ridges. Nos. 2.† Towards the north of these, the lime-stone passed (forming all gradations of colour, from a white grey to deep black,) into a rock, composed almost entirely of manganese.

Nos. 3.‡ These specimens of granite veins were knocked off from the tops of the lime-stone ridges, into which they ran; by the quicker wear of the lime-stone, they were left as protuberances of two or three inches high.

The remaining specimens (Nos. 4.§) are from the adjoining rocks. These (Nos. 5.¶) and the lime-stone rocks, are situated in the bottom of a nullah, in a deep valley overhung by a thick forest, and so infested with tigers, that little research could be made beyond the small open space the nullah afforded. The lime-stone rises in its bed and runs to the westward; the eastern bank appeared to be of gneiss, or varieties from it to quartz and mica schist. The kankars formed some large blocks immediately below the lime-stone.

Proceeding

* Nos. 1. Primitive Crystallized Lime-stone with veins of Granite, Quartz Rock, and Glossy Actinolite.

† Nos. 2. Gradations from the above Lime-stone into a Rock, consisting principally of black Oxide of Manganese.

‡ Nos. 3. Granite veins.

§ Nos. 4. Gneiss and Quartz.

¶ Nos. 5. Calc. Tuff and Kankars.

Proceeding from *Rámték* to the west, the low range of broken hills appear to be a confused mass of quartz boulders; further on, a granite country is entered upon, or rather a country formed from granite debris, gravel of mica, felspar and quartz, composing the surface, with here and there crumbling blocks of granite and gneiss; but scarcely anything like the live rock is to be seen till you arrive at the river *Pesh*, below the village of *Nayakund*. Here, from under the high bank of the village, a dyke of gneiss, perfectly vertical, crossed the river, and formed a dam, interrupting the navigation. The dyke was lost in the opposite bank. Being employed in breaking a channel through this rock, the whole of its interior was laid open, and Dr. VOYSEY was so much struck with the contortions it displayed, and its variety of appearance, that he visited this place, by himself and with me, four or five times, and we have much to regret the imperfect state in which he left his MS., which has deprived the Geology of India of the remarks of this most acute and extensive observer. Few will ever be found superior to him in intelligence, and none in close observance of facts; and we can scarcely expect for some years, a person who, combining these qualities, will enjoy his great opportunities of seeing the formations of India throughout nearly its whole extent.

The gneiss (No. 1. A) varied from granite to mica schist; but the granite parts were veins, or rather imbedded masses of granite, for of most, the whole extent could be observed to be included every where in the gneiss. Quartz rock was frequently buried in it in the same manner, and wherever the granite or quartz occurred, the grain of the main rock was disturbed, and bent from its otherwise straight direction.

The adjacent rock was a grey granite, composed chiefly of whitish felspar,

felspar, in very large crystals ; in a mass of this, in the bottom of a ravine, the rock was distinctly traversed thrice or four times by granite veins, accompanied by as many heaves. The granite of the veins becoming smaller-grained, and redder, as more recent. I do not recollect that the veins had any mica, the chief ingredient was red felspar.

The gneiss dyke, though the contact was not actually to be observed, must have proceeded through the granite before it reached the bed of the river.

Gokula is three or four miles up the river *Pesh*, from *Nayakund*. The river is here again dammed up by a very extensive dyke of crystallized lime-stone. Its colours are brilliant, chiefly red and blue, or grey veined with blue, and is highly polished by the continued running of the waters, and broken into singular shapes, and hollowed into deep cavities and fissures. The stream, of the most transparent water, dashes through it in a narrow twisted and obstructed channel, and ends in a large natural tank, worked out of the marble by the river ; its depth we could not fathom, with the means then at hand, and being shaded by luxuriant trees, and backed by the fantastic shapes of the polished marble blocks, it formed a scene that was highly beautiful. Behind (north) was an amphitheatre of hills, and in front an open cultivated country.

The left bank of the river is composed of decayed gneiss ; the right bank of clay and a loose conglomerate of pebbles : the lime-stone occupies the bed of the river only, and appears unattached to either side.

Here, as at *Kumári*, (No. 1. B.) the lime-stone, which is much the same rock as there, passes into a quartz rock, coloured by manganese ore ;
the

the dark (No. 2.) stripes given by which are very variously contorted. Towards the left bank, granite and gneiss were formed, passing into the lime-stone, the gradation from the one to the other being very gradual, and showing intermediately, an intimate blending (No. 3.) of the two rocks, which could only have taken place when both were in some degree of fluidity.

Before leaving *Gokula*, I may be allowed to notice the very numerous tumuli of the neighbourhood. The rings of stone which marked them all were, in some instances, as much as fifty or sixty paces in diameter; they were mostly unraised, but some were elevated by a heap of stones. Dr. VOYSEY noticed, that they were similar to those about the *Hyderabad* country. The natives appeared to have no tradition concerning them, nor any idea of what they were.

Dr. V. and myself had one traversed in the centre by ditches of considerable depth, but we did not succeed in meeting with any remains.

The following is a part of the collection Dr. VOYSEY made, between *Nayakund* and *Gokula*, and named for me by him :

Slaty iron glance.

Granite, large proportion of quartz, with specks of mica, porphyritic syenitic granite; the hornblende being in large crystals.

Quartz, passing into chert.

Black mica schist.

White ditto ditto.

Sand-stone,

No. 2. In two specimens are veins of a Lead ore, or of Antimony.

No. 3. Lime-stone, passing into Gneiss.

Sand-stone, with iron glance.

Granite, red felspar, quartz, and a small quantity of mica.

Granite, red felspar, and hornblende, like mount Sorel.

Granular quartz and epidote.

Gneiss, passing into sand-stone.

Dolomite.

From the bed of the river.

Heliotrope.

Imperfect calcedonic agate.

Red jasper.

A green silicious indurated stone.

Onyx of calcedony and quartz.

Quartz, coloured by iron.

These last specimens would seem to show that the *Pesh*, in its course, crossed a trap country, and, though it rises in a granite country, and chiefly passes through gneiss mountains, yet it may be presumed, (as I observed in going to *Sindwara*, that the ascents and tops of the ghauts were of trap,) that it also meets with partial formations or veins of trap and basalt.

Crossing the *Pesh*, three miles to the east, are two detached hills at *Pársúni*, these are of a decaying rock, varying from granite to gneiss, and to quartz, the latter, perhaps, the prevailing rock, at least on the surface, and five or six miles further east are two other detached and larger hills of much the same variety of composition, at the village of *Níma*. On one of these was discovered the specimens of galena, which were contained in quartz rock. Some specimens were very rich in ore, but nothing like a vein of the lead could be traced, and what was met with was contained in small quartz boulders, scattered on the side of the hill.

Returning

Returning back to *Nagpur* by a middle route, between the granite mounds of *Woragaon* and the range of hills on the north, a little hill and a ridge of rock, running E. and W., is met with near *Bishwambher*.

The rock is of a cherty quartz and cellular, (No. 1.*) and much inter-mixed with a quartzzy ore of manganese. The top of the ridge has the exact appearance of the remains of a strong wall, and may be traced for a considerable distance along the plain, and scarcely rising above it.

The rocks were stratified and vertically disposed. Immediately north, a part of the bank of the river is formed of massive white quartz, and inland, are traces of granite.

On the *Kanhán*, at *Matni Mahodá*, after passing east over the plain from *Nagpur*, another dyke of contorted gneiss is met with, exactly similar to that of *Nayakund*; it is here accompanied by cellular iron clay—The extent of the gneiss beyond this, I am not able to mention; but it proceeds beyond *Bandéra*, and my belief is that it forms part of a great granitic formation, meeting by the way of the *Lánji* hills and *Retenpur*, at *Rangerh*, the great granitic range which sweeps round by *Balasore* and *Cuttack*, to the *Coromandel Coast*.

Near *Komta*, under the *Lánji* mountains, are hills of red ochre of good quality; and in one of the nullahs running from that direction into the *Wyne Ganga*, gold dust was found, samples of which, and the extracted metal, I had the honor to forward to the late Dr. Abel, for the inspection of this Committee.

The

* Quartz and Cherty Quartz.

The specimens from *Seoní* (* Nos. 1, 2,) bring down the *Chapara* basalt so far to the south; but immediately bordering at *Chaorí*, is a bed of iron clay, No. 5, resting most probably on gneiss; its breadth there, on the road to *Nagpur*, is trifling, and south of it commences a granitic formation, which extends to that city. Nos. 3,† are from small mounds of lime-stone of *Seoní*, three or four miles, which I had no opportunity of visiting.

Sindwara lies a little to the westward of north of *Nagpur*, and about sixty or seventy miles from that city. The specimens of granite 1, 2, 3, 4, are all from the immediate neighbourhood of the town.

The gneiss of the valley of *Nagpur* extends by *Kelode* to *Lodekera*, overlaid in many parts by extensive but shallow masses of pudding-stone, similar to that at *Patansinhí* and *Sawnèr*. After ascending the last ghat, which was covered with trap, the rock met with is granite — and this I traced nearly to *Baitúl*—the descending ghat to the valley of *Baitúl*, and last few miles, only being of trap. The top of the valley of *Baitúl* is granite, and this formation extends north nearly to *Hasana-bad*, with some small interruptions of sand-stones and trap: the bottom of the valley is trappean; part of the great trap of the west, with which it is connected by the valley of the *Tapti*, and the *Gawilgerh* and *Asíngerh* ranges of mountains, and it is united by *Múltai* and *Pandúrna*, with the hills of trap, whose extreme promontory in this direction east, is the hill of *Sítubaldí*. About mid-way between *Sindwara* and *Baitúl*, are some romantic piles of massive and immense granite boulders, some, perhaps, logan rocks, most of which have been consecrated by the superstition of the

* *Seoní*, Nos. 1, 2, Basalt, very similar to that of *Sítubaldí*.

† Granular secondary Lime-stone.

the *Gonds*, and are striped, and crossed, and crowned with streaks of red lead. Some parts of this high ground affords as fine scenery as any I have met with in the country. The surface is beautifully undulated, and the trees scattered at considerable intervals, leaving glades between of fine pasture. The elevation is about three or four thousand feet; the climate temperate, and the firm growan soil is by no means destitute of water—being constantly intersected by the little rills which form the sources of the *Kanhán*, *Púna*, and *Tapti* rivers. This fine country has, however, only a scanty population of rude *Gonds*, and is almost totally uncultivated.

XIII.

NOTICE

OF THE

OCCURRENCE OF GYPSUM

IN THE

INDO-GANGETIC TRACT OF MOUNTAINS.

BY CAPT. J. D. HERBERT, SUP. MIN. SUR.

IN the Wernerian arrangement of rocks, we find distinct places assigned to the titles of *Primitive*, *Transition*, and *Flatz*, Gypsum, leading to the conclusion that this mineral is found, to some extent, in rocks of these several ages. Some geologists, however, appear to doubt the existence of *Primitive* or *Primary* Gypsum. DR. MACCULLOCH, in his "classification of rocks," hesitates to admit it. So does a writer in the 20th volume of the *British Review*, who yet adopts the Wernerian arrangement, as, in the main, conformable to observation. Professor JAMESON states, that it has not been found in extensive masses in any primary rock. Professor CLEAVELAND admits its occurrence in the Alps, but it is most probable that he alludes to the fact mentioned by M. HUMBOLDT in his "*Gissement des Rochers*," who states that at the Splügen pass, in the Alps, primitive
gypsum

gypsum occurs mixed with dolomite, in beds subordinate to mica slate. With regard to Transition Gypsum, its occurrence is less questionable; but all authorities concur in fixing the principal and most important deposit of gypsum, to the newer red or saliferous sand-stone, (the red marle of England, and bunter sand-stein of Werner) or in its associated rock, the mountain lime-stone.

2. It was with these considerations in my view that I have always looked to the hills which bound on the south side, the several *duns* or vallies that stretch along the foot of the great mountain tract, as the most probable locality in which to find this substance. They answer perfectly in character to the description given of the red marle of England. That they are really a type of the saliferous sand-stone, is proved by the occurrence of extensive deposits of rock salt in their prolongation towards the Indus.

3. The gypsum, however, of which I have the honor to submit specimens, is not found in those mountains, but in the clay-slate formation which bounds these vallies to the north, and which certainly possesses none of the characters of a secondary rock. It will be differently named by the followers of different systems; those who admit a transition class, will probably distinguish it by that term; while those who reject that class will, at once, call it primary: it possesses the characters of the transition clay-slate in its granular composition, in being associated with a fetid lime-stone, and in lying between the secondary and the better-defined primary strata. It is to be noted, however, that the gypsum occurs in very small quantity; it appears to me, indeed, certain, that whatever be the age of the including rock, the gypsum itself is of comparatively modern formation, and similar in its origin to those masses of stalagmitic lime-stone which are found in every rock, from the oldest gneiss to the

newest flœtz rocks, and that it is a merely local occurrence. This opinion I derive from the very limited quantity in which it is found, from its being associated with a sulphuretted lime-stone, and lastly, from its containing fragments of the neighbouring rock.

4. The principal deposit occurs in the bed of a stream which leaves the hills immediately below the village of *Nágul*, in the *Dehra Dún*—This stream, so well known to visitors who come here from the *Haridwar* fair, as deriving its name from a spot called *Sansar Dhára*,* or the dripping rock. This is a perpendicular bank of fifty feet in height, which, for a breadth of sixty or seventy feet, is faced with pendent stalactites, from which, and from the brow of the hill, descends a continual shower of drops. The water contains carbonate of lime in solution, (probably through the medium of carbonic acid) and is continually depositing it, so as to add to the number as well as size of the stalactites.

5. Two miles beyond this spot, at the confluence of another stream which comes from the left, the water of which is also charged with carbonate of lime, is seen the gypsum associated with a rock of rather an anomalous character. It has all the aspect of a lime-stone, but refuses to effervesce with acids, or at least does so very feebly. It is frequently of a deep black color and fetid odor, particularly when struck or fractured. The odor is that of sulphuretted hydrogen. As it passes into well characterised limestone, it must be considered, geologically, as one of the numerous types of that rock, though, as it is so highly charged with argillaceous, and probably siliceous matter, its claim to the title of a lime-stone would not be so obvious in a hard specimen, it is one of an extensive

* Or, according to some authorities, *Sastar Dhára*.

extensive series of beds included in clay-slate which, as I have before observed, may be either transition or primary, according to the observer's views. Fragments of the clay-slate, as well as of the lime-stone, occur in the gypsum; the former rock is distinctly stratified, and dips east with an inclination varying from 30° to 50° ; the lime-stone is not so generally stratified, or at least the stratification is often very obscure.

6. The gypsum is of the prismatic species of Professor Moh's, of the variety called foliated granular; it is of a snow-white color, the lustre is equal, or perhaps a little superior to that of white marble—It is scarcely translucent, or if so, only in a low degree. One small specimen which I saw was perfectly so, and had all the appearance of the most beautiful alabaster. The specific gravity I find to be 2.24, which is within the limits determined by Professor Moh; the hardness is about 2.0. In strictness, however, the hardness of a mineral cannot be determined from specimens in which the individuals are so small, at least not in the determinate manner required in the scientific system.

7. A second deposit had been discovered, about two miles up the bed of a stream which falls in opposite to *Sansar Dhára*, by a gentleman who had visited the spot, and mentioned the occurrence to me. I was not successful, however, in my attempts to find it, although I met with a sufficient number of fragments to indicate the neighbourhood of some larger mass. The description given, with an examination of the specimens, enable me to decide that it was a small bed, or mass, in clay-slate. Some of the specimens had the slate adhering; it appeared evidently to have been formed by infiltration, or deposition from water, subsequently to the clay-slate, as the bed which, in its greatest extent, was nearly horizontal, had taken a downward direction, so as to fill up a perpendicular crevice in the slate. The gypsum exactly resembled that of the preceding locality.

Though

Though I could not find the principal bed, I detected a small mass of an irregular figure, enclosed in angular debris, which, from its impurity and the freshness of its surface, had been, I conclude, formed in that situation. The water of this stream is impregnated with sulphuretted hydrogen.

8. The third locality is on the ascent from the village of *Rájpúr*, immediately below the hamlet of *Jarí Pán*, situated in the range which rises to the north of the *Dún*. It has been found, as yet, only in veins, in a blue lime-stone, and chiefly of that variety called fibrous. Here, too, as at both the other localities, the rocks develop, on being fractured, a strong odor of sulphuretted hydrogen. How far this fact may be connected with the origin of the mineral in these places, remains to be determined.

9. The strong family resemblance which the lime-stone rocks bore in this place, to those in contact with the gypsum, at the former two localities, was sufficient warrant of the actual existence of the mineral, in greater quantity, in the immediate neighbourhood. And I was afterwards fortunate enough to discover it not many miles from the spot where these fragments had been picked up. This fourth locality is on the northern face of the range, in the ascent from the hamlet of *Ranon* to the summit. It is found in some quantity, and of the same character, and under precisely the same relations, as at *Sansar Dhára*. The masses of which there are several, are all superficial, and contain fragments of the black fetid rock on which they lie, which also, like that at *Sansar Dhára*, though non-effervescent itself, passes into one that is—and which also, when rubbed or struck, gives out the odor of sulphuretted hydrogen.

10. In the first volume of the new series of the Geological Transactions, a specimen of gypsum, as also of anhydrite, * is enumerated as amongst those presented to the Society by MR. COLEBROOKE, in the name of Captain, then Lieut. GERARD. I have also heard of a specimen in a Calcutta collection, which had been presented by Dr. GOVAN. I am not aware of the locality of the latter; the former was found somewhere in the bed of the *Spítí* river, on the confines of *Ladák*, and at no great distance from a primary formation. No particulars are, however, given of the mode of its occurrence. These are the only instances of gypsum being found in these mountains, that I know of, besides those detailed in the present paper. Who was the first discoverer of the Dehra gypsum, I cannot say. I have been told that the substance had been familiar to the residents in the *Dún*, who confounded it with white marble, and that Captain GRANT, of *Sahárunpur*, was the first to suggest its real nature.

11. Gypsum is used as a material for statues, vases, columns, and similar works of art. The purer and more crystalline varieties, are even used for ornaments. When the water which it contains, and which amounts to twenty-two per cent. is driven off by burning, it forms the plaister of Paris, or material for stucco work, and for casts. It is also used (unburned) as a dressing for land, extensively, I believe, in America. The quality of the mountain gypsum is such as to fit it for all these purposes, except the second; but the quantity which has, as yet, been discovered, is not, perhaps, sufficient to render it an object of much attention. A careful search might be successful in laying open greater stores, though,

* I have in my possession a rolled piece of Anhydrite, presented to me by G. W. TRAILL, Esq, Commissioner; but I have mislaid the particulars of his note: it was, however, from the neighbourhood of the Snowy Peaks.

though, from what I have premised, there is little hope of finding any very extensive beds in the immediate vicinity of the present quarry.

List of Specimens forwarded by Dawk Banghy.

No. 1.—Is a specimen from the quarry, and will serve to give an idea of the best picked quality. (Art. 5.)

Nos. 2 and 3.—Are specimens of fragments from the bed of the stream. (Art. 7.)

Nos. 4 and 5.—Are specimens of the mass found in angular debris. (Art. 7.)

No. 6.—Contains imbedded fragments of associated rocks.

POSTSCRIPT.

Since first drawing up this paper, I have had access to one by M. BROCHANT, on the gypsum of the Alps, which it appears, till he undertook the examination of it, was considered to be a member of the primary class of formations. M. BROCHANT finds this opinion untenable; and from a large induction, he thinks himself entitled to conclude, that all the masses of gypsum in the Alps which he has examined, (and which he particularly remarks are superficial,) with whatever rocks associated, belong to one æra—an æra later than that of the newest of the rocks it accompanies. Now, in one of the lime-stones of this association, he has detected organic remains; so that if his conclusion of the cotemporaneous formation of these apparently unconnected masses be sound, they become, at once, referable to an æra posterior to that of primary formations. This so far confirms my view of the origin of Himalaya gypsum.

I ought

I ought to add, that, in mineralogical character, as far as that can be fixed by description, the gypsum of the Alps bears the closest resemblance to that of the Himalaya. Add to this, that they are, in both cases, found in superficial masses, which can hardly be called either beds or veins, that they are apparently independent and limited in extent.

XIV.

ON THE FERTILISING PRINCIPLE OF THE INUNDATIONS OF THE HUGLI.

By H. PIDDINGTON, Esq.

IT is a generally received opinion, that the fertilising principle of the inundations of the great tropical rivers, is vegetable matter in various stages of decomposition; in as far as relates to the *Húgli*, this is not the fact; as the following details, abridged from a paper presented to the Agricultural Society, will show. In a country, where European skill *must* shortly be far more extensively employed in developing its resources, than it has hitherto been, nothing which relates to the soil can be indifferent, or foreign to the views of the Physical Committee.

“ It is well known, that while the tracts within reach of the inundation, preserve their original fertility, the higher soils are gradually and rapidly impoverishing, and this to a degree of which few, who have not made the subject one of attention, are aware; there are some crops which cannot be repeated, unless at intervals of three or four years; while

on

on the low lands, these are the only ones which are taken for a period beyond the memory of man. Indigo is a striking instance, and the most familiar one, of what is here advanced; and it was with a view to some improvement in the cultivation of this plant, that the following Analysis were instituted.

Portions of the silt, (or mud, deposited by the inundations,) were procured from *Bánsbariah*, near *Sukhságar*, and from *Mohatpur*, near *Kissinnuggur*; the analysis of each gave in two hundred parts.

	Silt from <i>Bánsbariah</i> .	Silt from <i>Mohatpur</i> .
Water,	2	2
Saline matters, (mostly muriate of potass,)	0½	0½
Vegetable matter, destructible by heat,	4½	4½
Carbonate of lime,	12½	16½
Phosphate of lime,	0	1
Sulphate of lime,	0	0
Oxyde of iron,	12	12
Silex,	156	139
Alumina,	6½	14½
	<hr/>	<hr/>
	183½	180½
Loss,	60½	9½
	<hr/>	<hr/>
	200	200

The very unlooked-for circumstance of only two and a half per cent. of vegetable matter being found in these specimens, appeared almost to exclude the idea that this was the fertilising principle; or at least that it could be exclusively so; while, on the other hand, from six to eight per cent. of calcareous matter appearing in them, when in an extensive series of analysis of the higher soils, this was always found remarkably deficient, (seldom more than 0,75 to 1 per cent.) pointed to the conclusion, that the

calcareous matter was, perhaps, the great agent; and, in as far as regards Indigo, this was found, by experiment, to be the fact, for a minute portion of lime was found to increase the produce upwards of 50 per cent. The details of the agricultural experiment I omit, as foreign to our pursuits.

In considering farther this subject, it occurred that lime might probably exist, in solution, amongst the rich mud on which the seed is sown, as the waters recede, and this was found to be the case; a quantity of it, taken at the moment of the subsidence of the waters, being procured, it was found that the drainings from this were highly charged with carbonic acid gas, and that lime was held in solution by it, a fact which throws, perhaps, some light on the phenomena of the formation of kankar."

ON THE
MINERAL PRODUCTIONS
OF THAT PART OF THE
HIMALAYA MOUNTAINS,

LYING BETWEEN THE SATLAJ AND THE KĀLI (GĀGRA) RIVERS;

*Considered in an economical point of view: including an Account of the Mines,
and methods of working them, with suggestions for their Improvement.*

BY CAPTAIN J. D. HERBERT, 9th REGT. B. N. I.

Late Sup. Min. Survey, and Assist. to the Sur. Genl. of India.

THE survey of the mountains, of which I have had the superintendence, having been brought to a close, by order of Government, I have, in the selection and arrangement of my materials for the formation of a final Report, thought that the accompanying paper on the mineral productions of that tract might be acceptable to the Society. It forms a communication intelligible in itself, and independent of the other details; while it is not of a length to fatigue the attention. A subject as yet untouched by any pen, it may be not even without its interest.

The metallic ores are the principal productions considered in an economical point of view, and the details relating to them, including an
account

account of the mines and the method of working them, constitute the larger portion of the paper. I have added such suggestions as have occurred to me, for the improvement of the more obviously defective processes. But possessing little (if any) knowledge of practical mining, it is very possible that my suggestions may not be always improvements. The reader will take them for so much as they are worth, and no more.

As the subject is a popular one, I shall not affect any precision or refinement of method, but endeavour to communicate the little I know in the most intelligible form I can; guided only by convenience as to the order in which I shall notice the different substances. They may be divided, then, into two sections—the first to consist of those which do not furnish metal, the latter, including all the metallic ores.

I.

Of minerals, not useful to the metallurgist, though otherwise productive, the following are found :

1. Sulphur.
2. Green Sulphate of Iron.
3. ~~Bitumen.~~
4. Bitumen.
5. Graphite.
6. Gypsum.
7. Limestone, and
8. Potstone, or Indurated Talc.

I shall bestow a few words on each of these, and then proceed to the second section, comprising the Metallic Minerals.

1.—*Sulphur.*

This substance appears to deserve the first notice, if it be only for its value as an ingredient in the manufacture of gun-powder. During the late war, its price rose to £30 per ton in Europe, and it would seem a subject not unworthy of attention, to ascertain in what quantity and at what price we could draw it from our own provinces. There are several sources of supply within these mountains; but it is to be feared that the expence of carriage would neutralise any profit to be expected from the more remotely situated of these. It is found in the deposits of hot springs, occurring in the bed of the *Rāmgangá*, and of the *Garjá* rivers; in the province of *Kamáun*, mixed with carbonate of lime, from which it is readily separable by a subliming heat.—It occurs in considerable quantity in some of the galleries of the lead mines at *Mywár*, on the *Tóns*, in *Jaunsár*.—It may also be obtained in the first roasting of copper pyrites, as is practised at the *Parrys'* works in Anglesea, or of the ores of Galena, as was effected in the lead mines of Cronebane, in Ireland. It is not easy, without further enquiry, to estimate correctly the amount derivable from these several sources. Doubtless it would be considerable, and probably greater than any demand likely to arise immediately.

2 — *Green Sulphate of Iron.*

In connection with the deposits of sulphur and carbonate of lime occurring at the hot springs, there are also found extensive surfaces covered with an efflorescence of green sulphate of iron. This substance might be further obtained, in any quantity, from the iron pyrites of the mines. The conversion of the sulphuret into the sulphate is effected by reducing it to small pieces, exposing it to the air, and occasionally sprinkling it with water; operations requiring little labor, and involving no other expence.

3.—*Alum.*

ON THE MINES AND MINERAL

3.—*Alum.*

Alum has not (as far as I know,) been yet found in Europe, otherwise than associated with the argillaceous schists. In America, however, a notice lately appeared, to which some degree of interest seemed to attach, of its having been found in micaceous schist. Our mountains afford another example of this fact. Near *Almórah*, in the bed of the *Cosilla*, it may be seen as an extensive efflorescence on mica slate, and it is probable that, by quarrying and lixiviating the rock, profitable quantities of the mineral might be obtained. From observations made when I was occupied in other duties, and not so precise as to the exact nature of the mineral, I think it probable that there are many similar examples of its occurrence, and that it is by no means rare in our mountains.

4.—*Bitumen.*

Bitumen occurs, but in no great quantity, if we may judge from the price it bears. It exudes from the crevices of a lime-stone rock, on the summit of the range between the *Sarjú* and the *Rámangá*. On exposure to the air it hardens. It is used by the natives as a medicine.

5.—*Graphite.*

This substance has been found in round nodules of sizes, from one to three inches in diameter, scattered on the summit of a ridge composed of a highly carburetted micaceous schist. No bed, or mass *in situ* has been yet observed; but there is little doubt of the existence of such from considering the character of the rock, combined with the mode of occurrence of the mineral. Many of the nodules are more or less contaminated with quartz and mica, while, in one specimen, there were portions of quartz that had much the appearance of veins.

Almost

Almost all the nodules have more or less of the metallic lustre on the outside, owing to the degree of friction they have undergone. But the fracture surface is always dull; the composition being, apparently, fine earthy. On being rubbed or cut, it recovers its polish. That the absence of lustre on the fracture is dependent on its state of aggregation or composition, as mineralogists call it, seems further probable from its extreme porousness. One specimen, by some trials, appeared to absorb one-fourth of its bulk of water.

The specific gravity of those specimens apparently most free from foreign contamination, varied from 2.21 to 2.26. There is little doubt that, in the case of a mineral like graphite, the specific gravity is a valid test of its purity. It is interesting, then, to compare these values with that generally assigned by the best authorities. Amongst the older writers, there is such a range of results as warrant their rejection altogether. Professor MOHS, one of our best modern authorities, assigns 1.8 to 2.1 as the limits—HAUY 2.089, as an actual determination. SCHRADER again, who undertook a particular examination of the graphites from different countries, states the specific gravity of English specimens, remarkably pure, and one of them from Borrowdale, at 2.32 to 2.46. However this may be, the mountain graphite is, certainly, of inferior quality—although I have succeeded in manufacturing a very tolerable pencil from it, and even in cutting out a small cylinder, such as is used in the patent pencil cases. It is also to be noted, that the graphite in England undergoes the preparatory operation of being boiled in oil. It is possible that such a process may considerably improve the quality of the mineral.

The uses of graphite are not confined to the construction of pencils, and there is a demand for very inferior qualities of the article. Adverting to the increasing employment of steam engines, it may be safely said that

that a sufficient quantity of even the quality yet found, would not be without its value. It is well known to be the very best anti-attrition application for metallic surfaces, when mixed with tallow, or other greasy substances. A mixture of this kind is useful, too, as a preservative from rust for articles of cast iron, and it is equally found to improve their appearance.

6.—*Gypsum.*

Of the more bulky articles, Gypsum, of the discovery and geological relations of which an account is given in another part of this volume, is doubtless the most valuable. Its pure white color and granular composition, fit it for works of ornament. It is, however, probable, that its chief use in this country, for some time, would be as convertible into Plaster of Paris, and affording a material for cornices and ornamental work, to the banishment of the very rude productions of this kind we have hitherto put up with. There is, perhaps, sufficient quantity of it to answer any demand, likely immediately to arise. When the Government House was last repaired, it was considered desirable to obtain a sufficiency for the purpose above indicated; but the fact of its occurrence within our mountain provinces was not known at that time. As it is within fifty or sixty miles of water-carriage, it might be expected to pay for its transport.

7.—*Limestone.*

Marble is the rock next in value. Although it is not found of very brilliant colours, yet it is not deficient in beauty, and might, I think, be found to defray the expences of working. It is indubitably superior to the very coarse marbles of the western provinces. A white dolomite, of a fine grain, approaching to compact, is found in many places. A variety, exactly answering to the description of the Iona marble,

marble, occurs at no great distance from the plains, and would certainly be admired. Another, at no great distance, is a flesh-colored dolomite, with purple clouded delineations, which, to judge from hand specimens that have been worked and polished, promises well. All the preceding are fine grained, almost compact. A marble of a more crystalline grain is found on the road to *Bhadreenath*, above the *Bishen Ganga*. This is a large mass; but, perhaps, too far from the plains to be of any value. Rolled pieces of crystalline limestone are found in many of the torrents within the zone of greatest elevation, proving that beds of this rock are, or were to be found within that tract.

8.—*Polstone, (Indurated Talc.)*

This rock may be substituted for many of the purposes of the former. It admits of considerable, though not equal polish, and in its great sectility, and the consequent facility of shaping it, there is an advantage. It may be cut with a knife, and by means of chisels, rasps, and files, may have any delicacy of ornament impressed on it. It may be turned in the lathe, and in this way are formed in Europe vessels, which are used for preparing food, having the advantage of standing the most intense heat: as a material for small furnaces and crucibles, it is valuable on this account. In ornamental work, its inferiority of polish and peculiar oily lustre, prevent its emulating marble—yet it is not without its beauty and its correlative gem—the *chrysolite*, which has something of the same peculiarity of appearance, is highly valued. So well are the uses of this stone understood in Europe, that at *Chiavenna* in *Italy*, it is said, a very considerable trade is carried on in articles manufactured from it, amounting to forty thousand piastres yearly. In *Ireland*, where, as in these mountains, it has been found in a primary formation, containing also copper, it forms a profitable article to the proprietors of the mines.

Serpentine, a mineral nearly allied to potstone, has not yet been found, except as an ingredient in other rocks. On the other side of the *Killi* river, (the boundary of the British authority,) it is found in sufficient quantity. The natives apply it to the same uses as we do, i. e. ornaments, and small utensils of various descriptions. I have seen a very beautiful specimen—the handle of a small knife in a *Khúkerí*, sent as a present. I have myself two large specimens of a very good quality, obtained through the kind assistance of Mr. TRAILL, the Civil Commissioner.

9.—*Granite.*

By a certain latitude of expression, granite, though not exactly a mineral, may be ranked under the head of mineral productions. There is a very beautiful porphyritic grey granite close to the cantonment of *Almorah*, which would furnish fine ornamental pillars, or slabs of any size, and to any extent. Under this head also may be noticed, a variety of toadstone, which has been found in fragments, and the original mass of which is doubtless to be detected. It has a greenish grey basis, with white crystals interspersed, and when polished, has rather a beautiful appearance.

10.—*Borax.*

Borax, though not occurring within the British tract, yet as forming a valuable article of commerce, should not be omitted. The whole supply of the European market passes through these mountains. It is found in a lake, which would appear from some accounts, to have the power of reproducing it. It is sold at the *Bagés-war* Fair, (twenty-three miles from *Almorah*,) in two states, picked and unpicked. The first consists entirely
of

of crystals, varying in length from one, to one-eighth of an inch. These crystals are very flat hexagonal prisms, with trihedral summits. They are of an oil green color, and nearly, if not quite, opaque. In the other state, it contains a good deal of Borax-dust, which consists either of very minute crystals, or of fragments, broken off the larger crystals, of the sand, or earth, forming the substratum of the lake, from which it is procured, and (not unfrequently) of impurities, with which it is fraudulently adulterated. The picked Borax (or larger crystals,) is, itself, very far from being pure, and the method of purifying it, is said in England, to be a secret confined to a few—I could perceive no difficulty, beyond the length of time required for the deposition of the peculiar matter by which it is contaminated. I have found Borax of one solution, perfectly equal to the purposes of the arts. When pure, it is quite transparent, and nearly colorless. It is an article of such great utility, (for its actual uses are limited by the high price it bears) that it appears desirable the purification might be performed on the spot instead of transporting it to such a distance in its impure state, thereby enhancing the price. Indeed, owing to the high duty, which amounts to a prohibition, the price of Borax, in the *Calcutta* market, whether raw or purified, is the same, viz. fourteen to seventeen rupees a maund. At *Bagésvar* it is five rupees.

The preceding details are sufficiently meagre, but this must necessarily be the case as none of the substances found in our own provinces, have yet been sought for as articles of commerce: so that, except the mere fact of their occurrence, there is little to communicate. In the following Section, which includes an account of the mines worked, I shall be more full; though I fear there may still remain many deficiencies, and many particulars of interest to be supplied.

II.—METALLIC PRODUCTIONS.

The metallic productions of the mountain provinces, though hitherto inconsiderable, as far at least as regards the quantity of metal raised, might, it is probable, under judicious management, become profitable enough to repay any attention bestowed upon them. No mine of the precious metals has yet, it is true, been found within the limits of the British authority, although the discovery of such beyond the frontiers is said to be far from rare. There are, however, circumstances which seem to indicate the existence of gold within the limits of the British tract. Several of the mountain rivers which have their sources within this tract are known to furnish gold; and, though the produce at any particular spot be scanty, yet when we consider the whole extent of surface from which the metal is obtainable, the quantity is far from inconsiderable. At all events, the fact furnishes proof of the actual occurrence of gold in some part of the strata which these rivers traverse. In the case of the *Rám-gangá*, the supply is traced to a tributary stream, called the *Béni Gangá*, which has its rise in the lower mountains, as it is only below the confluence of the two that the sands are found productive. In that of the *Sona Nadi*, it is still more limited, as that stream has a very short course wholly within the *Patlí Dún*. And with regard to the *Alakanandá*, I may mention that I have a specimen of granite, I obtained at *Kédarnáth*, one of the sources of that river, in which occurs a speck of native gold. Considering, indeed, all the circumstances of the case, it is, I think, far from improbable, that gold will yet be found in its native matrix within our mountains.*

Of

* Such a discovery is, however, more likely to be the effect of accident at some distant period, when the progress of population and improvement together shall have left scarcely a spot unexplored. That a systematic search holds out few hopes will be evident from considering the history of gold mines all over the world. How fruitless the most prudently conducted examination of a tract positively known to contain gold, and in some quantity, may turn out, is to be seen in the detail of the proceedings adopted in Ireland, to trace the gold found in diluvial gravel in the County Wicklow, to its parent source. The reason of this, as well as of the inferior productiveness in general

Of copper, lead, and iron, the metals next in value, there is no deficiency; or I should rather say, there ought not to be any; for the actual produce in any of these metals, is trifling in quantity, and inferior in quality. There are many considerations which combine to prove that the mountain tract, extending from the *Setlej* to the *Brahmaputra*, is rich in copper. With regard to iron, it may be said to constitute a considerable part of the country; either as a constituent of rocks, in the form of ironstone, or in the numerous and extensive beds of the better defined ores. Lead also is found in abundance; and is worked as well as the two preceding in many places, and with considerable profit. With regard to the other metals, little is known. Antimony is found, combined with lead and sulphur; but the ore is not worked. Manganese has been detected as entering, in small quantity, into the composition of one of the iron ores. Perhaps, were its characters and value known to the miners, it might be discovered. Arsenic, in the state of sulphuret, is imported from beyond the frontier; but I have not heard that it has been found within our provinces. Of the rarer and less extensively useful metals, it is impossible to pronounce with certainty. There is, of course, a probability, that some of them which may be said to be geologically connected with the existing formations, will be found. Nor does their non-occurrence hitherto, militate against that probability; when it is considered, that their properties and value are alike unknown amongst those with whom the task of discovery has hitherto rested.

The metals which yield revenue; are COPPER, LEAD, and IRON. The GOLD obtained from the sand of rivers; paid during the *Gorkhah* rule, a small

of mines of the precious metals, may be found in their comparatively small produce, thereby occasioning an expence in searching for or raising them, which, in most cases, more than balances their superiority of value. It is the accidental discovery where no expence has been incurred, or the falling on a rich vein in a mine already worked which constitutes the prizes in this lottery. For one who makes his fortune, hundreds lose.

small duty ; but the amount was too trifling to render its continuance expedient, and it was accordingly abolished by the Commissioner. I think, however, the amount of metal obtained from this source, might be increased by attempting the operation on a larger scale. Hitherto the work of an unassisted individual ; who has neither means or inclination to do more, than will earn his daily pittance ; and who compelled to execute every part of the process himself, necessarily loses time, and does nothing well ; it is not to be wondered that the produce has been trifling. Mercury is used for the final separation of the gold ; but it is driven off again in an open vessel, and consequently lost. On the small scale on which they work, this is not felt to be a loss. The common account is, that a man's daily labor will earn him two annas : but this estimate is certainly much under the truth.

The method followed is abundantly obvious. The gravel in which the gold-dust is always found ; and which in some rivers is the superficial deposit, in others, lies under a bed of sand ; is collected in heaps, and washed on a stage, or imperfect riddle, made of bamboos. The pebbles of any size are retained by this, and then rejected ; while the sand which passes through the interstices, is carefully preserved. When a sufficient quantity is collected, it is put into a wooden trough, of about three, to five, feet in length, and a foot broad : being filled with water, the whole is agitated by the hand, and such a degree of inclination skilfully given, as shall carry off all the lighter particles ; leaving a heavy black sand, behind. It is in this sand, that the particles of gold are found. It is triturated with quick-silver, which takes up the gold ; and the amalgam being separated from the still remaining impurities, is set over a fire to evaporate the mercury : the gold remaining behind, in the vessel.

Of the mines, at present, worked in these mountains ; those which yield copper, are undoubtedly the most important. With regard to the

IRON mines, although they do not hold out an equal prospect of immediate advantage ; yet there is little doubt, but that the revenue derivable from them also, might be much augmented ; and, with very little modification of the present processes. Eventually, they may be found the most valuable of all ; but this must be the result of a state of things, not in existence at present. The LEAD mines are next in importance ; and judging from their former value, (which was greater than the total amount of all the mines of whatever metal at the present day ;) they would seem to be, even not much less worthy of attention.

1.—*The Copper Mines.*

There are seven copper mines ; or I should say, seven places where copper ores are extracted ; for at some of them, the mines or excavations, are very numerous. These seven localities, with the rent they pay, are as follows :

Dhanpúr,* .. ..	..	..	} 1200 Rupees per annum.
Dhóbri, .. ..	..	..
Gangóli, .. ..	..	..	} 1000
Síra, , .. ..	..	..
Pókrí, .. ..	..	..	600
Khari, .. ..	..	..	40
Shór Gurang, ..	..	..	50

None of these are very advantageously situated, considering the expence of carriage in the mountains. But as buffaloes† may be extensively employed

* The localities of these mines, and of the other minerals, will be indicated in the Geological Map, which I hope soon to lay before the Society.

† An average Buffaloe will carry two maunds, with great ease, up the steepest ascents.

employed on good roads ; and the breed appears to thrive in these provinces ; it seems easy to obviate any objection, arising from the present difficulties of transport.

Of the probable value of these mines, it is difficult to form any thing like a correct idea ; owing to the miserably contracted scale on which they have been, hitherto, worked. The chief thing of course to be considered is, the productiveness of the several veins or beds of ore ; for supposing the quality of the metal sufficiently improved, there is little fear of a market being wanting.* It is not, however, easy, to obtain precise information on this subject : for the mines themselves are inaccessible to a European ; or indeed to any, but people who, from their childhood, are accustomed to penetrate them. They resemble, as Mr. TRAILL has observed ; rather the burrow of an animal, than the path of a human being. For this reason, it is impossible to speak, from actual observation, as to the productiveness of any particular repository of ore ; and all we can do is, to form probable guesses. In *Chili*, it would appear, that the average produce of about 500 mines, is six tons each annually. From considering the rent of our *Kemáun* mines ; and the price of copper (two rupees a seer ;) allowing also, that the produce is double the rent ; we shall have only one ton, for the amount yielded by the *Dhanpúr* mine : and half a ton each, for those of *Gangóli*, *Síra*, and *Pókri*. The others, are too small to be worth considering. Supposing then that these four mines, have naturally an equal average of ore, with those of *South America* ; we see that there is great room for improvement, and a fair prospect of advantage. On the average of six tons for each of these four mines ; *Kemáun* would yield
twenty-four

* It appears by Captain Hall's work on South America, that notwithstanding the quantity of Copper thrown into the market by the Hon'ble Company ; the greater part of the produce of the mines of Chili, (3000 tons annually) finds its way to the Calcutta market.

twenty-four tons annually, instead of two and half as at present : and the revenue ought to encrease in the same proportion ; that is, from 2700, to 27000 annually. But this is not all. There is little doubt of the existence of the ore in many other places : and were an improved system to be introduced, and the value of the metal consequently to rise in the market ; a stimulus to investigation would be given, which might reasonably be expected to lead to the discovery of other sources of the ore, at present unknown.*

The principal mine, in point of value, *Dhanpúr*, owes its rank in the scale, not only to the great value of the ore yielded ; but also to the nature of the rock in which it is situated. This rock, a red dolomite, is of such consistence, as to require seldom, if ever, any props for the support of the roof ; and scarcely any additional expence, after the gallery or chamber is once excavated. Whereas, in the others, the rock is often so tender as to require timbers for its support ; and even so supported, it fails every year in the rainy season ; when a new expence is to be again incurred, without the prospect of any immediate advantage. This, is more particularly the case, with the *Pókri* mines. In the *Dhanpúr* mine, the work once effected, there is no occasion to repeat it ; and every foot of excavation made good, is a permanent acquisition. An equally important advantage is, the continuance of the working season all the year round.

The compact structure of the rock, or perhaps the great elevation of the mine, and its proximity to the summit of the mountain ; gives it
another

* I am told that the mine at *Pókri*, called the *Ráj Khán*, yielded one year 50,000 Rupees : and at *Dhanpúr*, it is known that in consequence of an earthquake which shook the mine and laid open new veins of ore ; the profits of the lessee were, that year, very considerable. Every one who travels in the mountains, must be struck with the numerous indications which present themselves of the existence of this metal. While writing this paper, a new vein of ore has been discovered, and leave asked to work it.

another superiority which is no inconsiderable one : a freedom from water, and consequently, from the expence and trouble of drainage. One of the effects of this advantage is, that the miners have been enabled to follow the deposit of the ore, in all its ramifications and changes of direction : and the interior of this mine, presents quite a different appearance from that of others ; being a succession of chambers, situated at various levels, and in various directions.

The ore is of that kind called GREY COPPER ; (the *Fahlerz* of the Germans.) Many species, chemically speaking, perfectly distinct, have been confounded under this name. Four at least are certain —one of which contains iron as well as copper ; two, iron and arsenic, but in different proportions ; and the fourth, iron and antimony. They are all sulphurets, and the yield of copper is from thirty to fifty per cent ; that is of the pure mineral : for no working ore, can ever be expected to give that proportion. The *Dhaupúr* ore, is the most valuable of the four : and contains fifty per cent. of copper ; besides iron, and sulphur. It is always amorphous, either massive or disseminated. GREEN CARBONATE is sometimes found, but in no quantity.

The *Pókri* mine, or mines, are situated in a talcose schist : which on one side, passes into a talcose gneiss ; and on the other, into a chloritic schist. All these rocks are so soft, and even rotten ; as to have rendered vain every precaution of the miner : and the galleries excavated, have been constantly subject to accidents. When I visited the place ; they had all fallen in : and, there was no lessee. I was unable, therefore, to procure proper specimens : and can only judge from the imperfect indications observed, in examining the rubbish of the mine. These seemed to point to, VITREOUS, and, PURPLE COPPER ; the two most valuable of the sulphurets : the former, yielding eighty per cent. metal. The waters

waters from this mine were observed to be impregnated with SULPHATE of COPPER.

The *Sira*, and *Gangóli* mines, are situated in beds of indurated talc, or potstone; which are again, enclosed in dolomite. Occasionally the former, occasionally the latter rock, forms the roof, and sides, of the mine. The dolomite, has a large crystalline grain; and great tenacity; and forms a perfectly durable work, when excavated. It is not so, however, with the other: at least, not always. When massive, it is, I believe, to be depended on: and it has then, a great recommendation in its extreme sectility; and the ease with which it is worked. But it occurs, sometimes, of such inferior consistence; having much the appearance of re-united debris; as to require support: and to occasion much inconvenience, and even, danger.

The ore, at each of these places, is COPPER PYRITES. I have never seen any crystallised specimens. It is accompanied by IRON PYRITES: which is occasionally found in the pentagonal dodecahedron; but most commonly, in such irregular and anomalous forms, as are with difficulty, describable.* I have observed specimens also of GREY COPPER: but in small quantity. The working ore is, no doubt, copper pyrites; and the quantity of copper it contains, may be taken at thirty-five per cent. This is, of course, to be understood, as before remarked, of the pure mineral: uncontaminated by the matrix.

The KHARI, and SHÓR GURANG mines, are similarly situated—the ore produced, is in so small a quantity, as not to require any lengthened notice. I have observed GREY COPPER, COPPER PYRITES, and CARBONATE OF COPPER: chiefly, if not always, disseminated. An important advantage, which all
the

* Possibly composite forms.

the mountain ores, I have yet seen, possess; is a freedom from any mixture or combination of arsenic : a metal which, above all others, deteriorates the quality of the copper; and is most difficult to remove.

The method of working these mines, is, with the exception of that at *Dhanpúr*, (which has already been described) as follows. A gallery, or passage, is cut into the face of the hill; with such slight declivity outwards, as is sufficient to carry off the water. Where the rock may happen to require it; frames of timber, rudely, and even carelessly constructed, are set up: to support the roof and sides; and save the miner, from being crushed. Accidents, however, do happen: and men are, sometimes, lost. The size, or section of the gallery, is always small: in those parts, where the hardness of the rock, occasions any difficulty in working it; scarcely sufficient to admit a person, in a creeping posture. In no place, will it admit of an erect position.

The ore, as well as the rock, is detached by means of a very inefficient pick: and by chisels, or cutters; and hammers.—It is removed from the mine; on skins, drawn along the floor of the gallery, by boys. In some mines, great part of this work must be performed in a creeping posture. The ore being delivered at the mouth of the mine; is reduced to small fragments, by the hand. At *Dhanpúr*, however, this work is done by the *panchakki*, or water mill. It is next roasted in an open fire, or forge hearth; the fuel being charcoal; and the heat occasionally urged by two air bags or skins, which are alternately shut and opened by the hand. After being thus imperfectly roasted, it is smelted: but for this important operation, the same forge hearth is made to serve; and the process is repeated, till the metal is sufficiently refined. I do not know of any flux being used; to accelerate the scorification, and separation, of the less valuable metals.

The whole system, thus briefly described ; is evidently, extremely rude, and inefficient. Worse methods, I do not think, could well be devised. They are, however, the natural result of the contracted views and want of enterprise, of the native character. It would, probably, be difficult to convince them ; that any system of working, requiring an increase of outlay ; could possibly be equally advantageous. It is hardly to be expected, therefore, that they will ever adopt any improvements of this kind : until at least, they can have the proof of direct experience ; in favor of the greater profit, they may bring. Any important amelioration of the system, must then proceed either from the Government, or from some European capitalist : and when the advantage of the new methods shall be clearly seen in an increased produce, and improved quality of metal ; it is possible that then, but not till then, the mountaineer also, may begin to adopt them.

In England, the copper mines present a scene, perhaps, the first in the world, (except in the coal-mines of the same country) for commercial enterprise, scientific combination and mechanical skill. Such a system has been the growth of circumstances ; and is only fitted to those circumstances, and to that country, in which it originated. To attempt working these mines, on any thing like a similar scale ; would be absurd : at least, before the productiveness of the several repositories of the ore, be clearly ascertained ; and facilities of transport created, which do not at present exist. But, there are many modifications and improvements, which seem perfectly fitted to the state of things in the mountains ; and which would involve little additional expence to the present outlay. In fact, there seems a wide interval, between the Chilian and English systems ; while the modifications here contemplated, would probably, stop short of, even, the former. Supposing the expediency of such improvements, or a part of them generally admitted ; they must, I think, to have justice done them, be introduced under the orders of government, in some mine, the lease of which

may be retained for the necessary period. They would, at least, have the good effect of enabling us to obtain better data; for judging, whether or not, any further improvements and extension of the system, would be advisable. In the former case, experienced and practical people might be invited from England; for the purpose of improving the various operations of mining, roasting, smelting, refining the ore, &c.

The improvements which appear to me suited to the actual condition of things are as follows. The present narrow and inaccessible galleries should be enlarged; so as to admit, not only of an erect position, but of a man's working with effect, in them. This, of course, only applies to such as furnish a sufficient supply of ore; or to new galleries just commenced. Vertical shafts should be sunk when advisable, so as to admit of the ore being followed with effect. In many cases, however, this would be perfectly impossible; from the nature of the mountain, in which the mine is situated. Strong and effective timbers should be put up, for the support of the rock, when at all likely to fail: and to effect all these purposes, proper tools, made of good iron; and not the inferior kind, at present used; should be provided. The method of splitting rocks, by the wedge; and by blasting; might be introduced with advantage: and generally, such other practical improvements, as, though readily suggesting themselves on the spot, are not easy to be enumerated connectedly.

With regard to the drainage; the present system is, perhaps, the cheapest that could be devised, as far as it goes: but it is only calculated to meet, one, of many numerous cases occurring in practice. Should the ore be situated below the level of the mouth of the mine; some method is then required to raise the water, which will flow into the new excavation, to that level, at which it may flow out. At present, I am inclined to think, that much valuable ore is lost; owing to the difficulties

difficulties which present themselves, when the bed or vein sinks to an inferior level. And it is certainly, to the absence of water, in the *Dhanpûr* mine; and the consequent facility of following the ore, in all its deviations; that its higher value in the scale, is mainly owing. Simple methods of raising water, might then, I think, be advantageously employed: such as the endless chain of water pots, used in the upper provinces; or a pump, or set of pumps, to be worked by manual labor. In raising water or any weight; where great power is required; one of the most useful mechanical inventions, is the double capstan: a contrivance, which is at once, eminently cheap, simple, and efficacious. In many cases, where the deposit of ore has a downward direction; a second gallery, at a lower level, may be conveniently established: probably, in most cases, this method of double galleries might be advantageous. A great progress must be made in the system here contemplated; before a Steam Engine, even of small power, could be introduced with any thing like a prospect of profit.

I have mentioned the principal points of improvement in working the ore. In delivering it from the mine; wheel barrows; or still better, sledges on four wheels, should be adopted; instead of the skins at present used. It seems, however, doubtful, whether the introduction of goats, to draw such sledges, would be any improvement. They are used extensively in the upper mountains, for carrying burthens.

In reducing the ore to fragments; the *Dhanpûr* miners employ the *Panchakí*, or water mill. When water is present, no better plan (I mean consistent with the economy here contemplated,) can be devised; when water is not to be had, in sufficient abundance; a simple arrangement of stampers, might be preferable to the method of doing it, by the hammer.

It is, however, in the roasting, and smelting operation, that the greatest room for improvement is to be found; and the greatest prospect of advantage from a change; as the immediate effect of this would be, to raise the value of the metal produced. For the present open hearths, and air bags; I would substitute a system of reverberatory furnaces; of different draughts, for the two different processes, of roasting and smelting. An excellent material for constructing them is at hand, in the rock, I have called potstone. Perfectly compact, and equal to any resistance; infusible in the strongest heat; while it is so soft as to be cut with a knife; it is difficult, even to imagine, any substance better fitted for such work. It might be advisable, in an economical point of view, to construct the roasting furnaces in such a manner, as to collect the sulphur at present lost; an object not difficult to be effected.

Even the introduction of the simple blast furnace used in Chili, (and nothing can be simpler) would be an immense improvement. It is of a circular shape; similar to a lime kiln; and covered with a dome, to confine and concentrate the heat. The ore is arranged in it, in alternate layers with the fuel, which is wood; and being lighted, it continues burning for a considerable time. When required; the heat is urged by a double pair of bellows, worked by a crank, turned by a water mill. The mere substitution of an efficient bellows, for the air bags, used at present, would be no trifling advantage gained; but I am of opinion, that a wind furnace is greatly preferable to all these half measures, in the saving of manual labor. Nor is it so much more expensive, even at the outset, as might be imagined.

The methods of reduction practised in England; where, certainly, the subject is best understood; vary with the ore, and even with the establishment: but the differences are trifling, and affect only the minor details. The two great objects to be effected, are—first, by a properly regulated heat to drive

drive off the volatile ingredients, sulphur, and arsenic; and to oxidate the iron, thereby promoting the fusibility of the ore, and consequent separation of the copper from the scoria when in fusion: and, secondly, by an intense and properly directed fusing heat, to effect the vitrification of the impurities; which thus form a slag at the top, and are skimmed off, while the metal sinks down in a comparatively pure state. To promote this vitrification of the ingredients, occasional additions are made to the ore, as the case may seem to require; though, in general, the run of the ores is such, as to require little beyond a few slags of an old smelting. Calcareous flux has been used at some works; and this is at hand in the mountains. A most valuable and effective flux, for the reduction of ores, in the small way, (for experiment) is borax. Whether it might not be used on the large scale, here, where it is so much cheaper than in Europe; may require some consideration, and some practical trials.

The operations of roasting and smelting are repeated several times—each smelting being followed by a roasting—to expedite which effect; the copper is after each smelting, but the last, let into water to be granulated. This separation of the metal into such small parts, assists of course, the calcining power of the furnacc, and the work is more speedily effected than if performed on the mass. After the last smelting comes the process of refining, or poling, as it is technically called. It consists in keeping the copper in a melted state, covered with charcoal; and introducing from time to time a wooden pole into the melted metal; which causes considerable ebullition, owing to the evolution of gaseous matter. It is occasionally assayed, in order to judge how the process is going on; by taking out a small portion, allowing it to cool, and breaking it in the vice. By the colour and general appearance of the fractured surface; a judgment is formed, as to whether the poling has proceeded far enough. This operation which gives the metal that perfect appearance, always looked for in the market; is

unknown to the mountaineer. It is probable, that it would materially improve the quality ; or at least, the appearance of the article.

Lead is sometimes used, both in Hungary, and England, to expedite the previous operations of the refinery. The oxides of this metal, are amongst the most powerful vitrifiers known : as such they are effectual in the assay and refinement of the precious metals ; and as such they may be used also with copper : but the process requires attention, as if not stopped in time, or too much lead added ; the copper itself will be oxidated and vitrified. Applied with proper caution, it would, no doubt, be a most useful material to the mountaineer ; and the occurrence of this metal, in the vicinity of the copper mines, obviates every objection on the score of expence.

On the supposition of Government establishing an experimental mine ; I would propose that all the different processes of mining, extracting the ore, removing it, for pounding, roasting, smelting, refining, &c. should be performed by the job, and not by the day. This, which is one of the most important improvements in modern management, is particularly necessary on a new experiment ; because it makes it the interest of the people employed, to co-operate with, instead of endeavouring to thwart us : the implements, tools apparatus, furnaces, &c. to be all furnished at the expence of Government ; and a given tale established for the different kinds of rock and ore, both for removal from the mine, and for the calcining and smelting of the latter.

2.—*The Iron Mines.*

The foregoing includes all that immediately suggests itself, as feasible improvement in the management of the copper mines : I have proposed,

posed, I think, no charge that would not, in a very short time, more than repay the expence incurred. With regard to the iron mines, I shall also mention a few particulars ; which, if attended to, would materially increase the revenue derivable from them also. I am informed by the Commissioner, that the united rent of these mines, which are very numerous, does not exceed the sum of 1500 Rupees per annum ; while the iron is of the very worst quality, and yet bears a price, in the Almora* Bazar, not much less than that of the best English iron, deliverable at Bareilly.

The process of manufacturing iron from its ores, is so far different from that of copper ; in as much as, none but the *oxides* of the former metal are ever employed. In the copper ores (that is, in those which occur in any quantity;) the metal is combined with sulphur : which can be only driven off by repeated roastings ; employing such a draught of air as to acidify it, the more effectually to separate it, in the latter stages. In the iron ores ; the metal is united to oxygen ; and mixed with various earthy impurities. In reducing these ores then, there are three distinct points to be attended to—First, the provision of a substance, which shall effectually take the oxygen from the ore ; leaving the metal mixed, only with its earthy constituents : 2ndly, The proportioning the flux used, to those earthy ingredients ; so as to ensure a complete vitrification of them, and separation from the metallic particles : and 3dly, A sufficient heat, to fuse the latter ; that the separation, and reduction, may be more complete. The first point is attained, by using a sufficient quantity of charcoal, in the reduction of the ores ; the second, by adding, as the ore may require it, limestone or other flux ; and the third point is only to be effected, by
using

* Almorah, 8 seers, 1 Rupee—Gwalior iron, good, soft, 6 seers—at Moradabad, hill iron ditto but hard, good for *fours*—Swedish steel, 2 seers—English cast, $2\frac{1}{2}$ —English iron, bar, 4—in flat bars, $4\frac{3}{4}$.

using a powerful blast furnace. Though it be, no doubt, possible to construct wind furnaces, of such draught as should smelt iron; still it is, I believe, more economical, as well as more certain, to trust only to a powerful blast.

The mountaineer reduces his iron ores in the manner already described for the copper ores. But from the imperfection of the method, the great waste of heat and non-employment of a proper flux in refractory ores, the iron is never smelted, but comes out of the furnace in porous knobs very much the size and shape of the original pieces of ore. These might, however, with proper management, be manufactured into a saleable iron; but the miner is contented with selling them in this state to the blacksmiths who, again, are very sparing in labor when shaping them into the pigs in which they are finally sold in the bazar.

In as far as such a lazy process may be compared with one which furnished metal of the very best quality, we may say the mode practised in the mountains is similar in its general features to the ancient methods which prevailed in Europe. These have, however, long been superseded by more economical processes, each of which is adapted to the particular kind of fuel and ore of the country in which it is employed. The English method, which employs coal as the fuel, does not require to be considered here; but the Swedish, in which charcoal is the fuel used, appears from this circumstance, from the simplicity of the apparatus and the small outlay of capital required, particularly fitted for these provinces, and not unworthy of attention and encouragement from the Government. It is well known that the superiority of the Swedish iron over the English, is mainly owing to the nature of the fuel used; although it is *also* true that the Swedish ore is chiefly, if not entirely, of the first quality—MAGNETIC IRON ORE. The former advantage ought also to hold in the case of the mountain iron; but none
of

of the working ores, it must be confessed, that I have yet examined, excepting one, is of the same species, as the Swedish.

Specimens, however, of this ore have been found in different places; and it is very probable that it does exist in sufficient quantity, to become an object of consideration to the Government. The *Bundelkhand* iron, which is said to be one of the best after that from *Gwalior*, is manufactured from the red oxide. The *Gwalior* ore I have never seen; but conclude it to be of the magnetic species, from a circumstance I recollect being mentioned by Captain GERARD, when surveying that country, of an unusual deviation of the magnetic needle. The mountain iron would, however, if carefully manufactured, have a sufficiently fair market, without any chance of being interfered with by either of those other kinds: and even supposing that the common ores should hold out little inducement to expend much on improvements in their reduction; still in the one known source of the magnetic ore, there is, apparently, a sufficient supply to authorize at least an experiment on a small scale.

It may, perhaps, be said, that a full improvement of the quality of this iron, would interfere with the sale of English iron: but it appears to me, that it would chiefly supply the place of the Swedish in the market; which is known to be in great request amongst the natives, under the name of “*Francese Loha*.” English iron has not an extensive sale in India; even in England it is now well established, that all the best steel is manufactured from Swedish iron. English bar iron, however, bears a higher price than the *Gwalior* iron; though the latter is more extensively used amongst the natives. The former is sold at *Moradabad*, for 4½ seers the Rupee; the latter at 6 seers. The mountain iron sells on the spot for 3 seers generally, that is about £14 a ton, which was the highest wholesale price to which the English iron attained during the war; at

sent it is little more than £10. The mountain iron could be afforded at a much cheaper rate.

The chief points, in which improvement is desirable, will be evident from what I have stated (Art. 30). The erection of proper blast furnaces; the judicious employment of fluxes; and a more careful system of manufacture; are all that is required to raise the quality of the metal, according to the ore used, either to a standard with the English iron or the Swedish. In the erection of blast furnaces, there seems no difficulty in a country where water is to be commanded at every turn. Limestone, one of the fluxes most used, is at hand; and all that seems required is a careful superintendence, to shew the advantage of the new methods in the first instance.

These being once established, it appears probable they would be generally adopted, when the object is to furnish so generally useful a metal in a purer and more workable state. I have said nothing of the process required for bringing the fused metal into a malleable condition, as it offers no difficulty. Water may here also be advantageously used as the moving power for the great sledge hammers, with which the fused metal is to be beaten.

The iron ores all belong, with the exception of those of two mines, to the species called RED OXIDE (*fer oliviste* of HAUY). This is a peroxyde of iron; containing, in its best-defined type, seventy per cent. iron, and thirty, oxygen. The working ore, however, often contains earthy impurities, which reduce the proportion as low as fifty per cent. of metal.—RED HEMATITE, a variety of this species occurs in a very extensive bed in Gneiss at *Dhaniakót*, on the *Cosillah*. It frequently contains small veins of MICACEOUS IRON ore of a highly splendid lustre. At *Ramgár*, on the road
from

from *Bhamāori* to *Almórah*, it passes into the variety called SCALY IRON ORE, consisting of loosely cohering glimmering particles of a steel grey or iron black color, strongly soiling and feeling unctuous to the touch. These beds, though distant many miles, are, I think, connected beneath, and from one and the same deposit.—Both of these varieties are said to yield very good iron; the first, particularly. COMPACT RED IRON ORE, occurs in a clay slate containing beds of lime-stone at *Katsári*, on the *Rám-ganga*, in masses composed apparently of fragments more or less angular, reunited by a stalagmitic incrustation. The iron manufactured from it is esteemed the best in the province of *Kamáun*. It is the only ore which has any adjunct of calcareous matter; and to this adjustment of the flux by nature, is attributable, I think, the superiority of the iron produced. Near *Kalsi* on the *Jemna*, there is an extensive bed of SPECULAR IRON ORE. The specimens which I have examined were fine granular, approaching to compact.

In *Chargarka* purgunnah, one of the excepted mines, the ore is the YELLOW (or *hydrated*) OXIDE. It is of two varieties, the ochry and compact. * The former sometimes contains octahedral crystals of magnetic iron ore, and in the neighbourhood of the mine, on the summit of a small hill, there occur rolled pieces, composed of grains of quartz, and small octahedral crystals of this mineral, cemented together. These pieces are magnets, and have each two poles. The ores of this mine contain manganese in small proportion, and would, consequently, afford a very good steel; as it is to the alloy of this metal that the superiority of the steel manufactured from some of the brown iron stones, is generally attributed. The other exception is the mine at *Sil*, in *Bisheer*, where a mica slate occurs with disseminated crystals, or grains of MAGNETIC IRON ORE; in such quantity, as in favorable specimens, to equal half the weight, or one-third the bulk. Some pieces of this slate have a specific gravity of 3.45. That of the ore itself is 4.8. The stone is reduced to powder by hand mills; and by means of a running

a running stream, all the impurities are separated. There remains a black sand ; which however still contains about a fifth of its weight of impurities : this is smelted with charcoal, into a porous mass ; which imperfectly beaten, is sold to the lower mountaineers at the rate of eight and a half seers for the Rupee. The iron is said to be of excellent quality, and is in great demand for *Khúkerís*. This is the mine at which I think it very desirable some improvements should be attempted, as holding out a fairer prospect of advantage. There does not appear to be any reason why this ore, if carefully reduced, should not furnish an iron fully equal to the Swedish. The supply, too, is sufficient to justify the expectation of a considerable addition to the revenue. At present, the people state the produce of manufactured iron as not exceeding three hundred Rupees ; but from the flourishing and substantial appearance of the village, I should think it must greatly exceed this sum.

3.—*The Lead Mines.*

THE LEAD MINES are numerous, and the supply of ore from some of them has been considerable. The most valuable are situated on the river *Tonse*, at no great distance from the *Dehra Dún*. There are three places where works, to some extent, have been, and are carried on ; *Aiyar*, *Maíyar*, and *Boréla*. The first-named place is on the right bank of the river below the village of *Bhatnór*, and within the limits of *Sirmúr*. The other two are on the left bank, and are in *Jaúnsár*, one of the mountain stpurgunnahs retained by Government ; the superintendence of which, is vested in the Officer commanding at *Dékra*. The *Boréla* mine formerly paid two thousand rupees yearly ; the *Maíyar* one, four thousand : the present rents are six hundred and fifty ; and one thousand. The mines were always included in the assessment for revenue ; and latterly owing to their alleged non-productiveness, the sum assessed has been limited to the
mere

mere land tax of the mine at *Aiyar*. I could not learn any particulars regarding the rent, the people being uncommunicative.*

With regard to the truth of their assertion, that these mines have ceased to be profitable, it is very difficult to judge. They are still worked, which is a presumption against it, but without a personal examination of the several galleries, and they are exceedingly numerous, it is difficult to say positively whether this assertion be correct or otherwise. I have however little doubt but they might be made productive, by a more enlarged and perfect system of work; and I found this opinion on the great number of excavations, clearly proving the original abundance of the ore. It is not likely, that the several veins or beds, have been exhausted by a system of mining which admits of no ventilation; and has no galleries, exceeding probably two hundred yards in length. At all events some trials, and a closer examination, would seem to be advisable; particularly when it is considered that there has been a falling off in the revenue, amounting to upwards of four thousand rupees yearly. To offer the mines to the highest bidder, would not be likely to elicit any light on the subject. It is not probable that any mountaineer could be got to undertake the work in opposition to those residing on the spot,† and having the advantage of experience.

The mine at *Bhatnór* is situated in clay slate. The rock where the mine penetrates is so tender and fragmentary, as when removed from the mine to have all the appearance of angular debris. Owing to this circumstance, the roof of the mine, as well as the sides, have occasion
to

* The village belongs to the Rájah of *Sirmúr*.

† On account of the difficulties a stranger (if a native) would have to contend with; there would be, most probably, an organised opposition of the whole neighbourhood, to thwart him.

to be strengthened by timbers. Notwithstanding which, they sometimes fall in, and the miners are killed.

The ore is found, as I said, occasionally in quartz veins in the clay slate; occasionally in the slate itself. The ore at *Máiyar* also occurs in a clay slate; that at *Boréla*, in a bed of lime-stone, situated in the clay slate. At each of these places the rock is sufficiently firm to afford the greatest security, and no propping or timbers are required; but the labor of excavation is greater. At *Bhatnór*, owing to the softness of the ground, the galleries are roomy; and will allow of an upright position: at the other places, they are similar to the copper mines; low, narrow, and tortuous. The supply of ore has evidently been considerable, for the number of these galleries is quite surprising: at *Boréla*, I was told they exceeded eighty; and I see no reason to think that the statement is too high.

At all three places the ore is the same, a steel grey FINE GRANULAR GALENA, having a specific gravity of 7,2; at *Máiyar* it is accompanied by IRON PYRITES, and in one gallery by SULPHUR. The mode of reducing these ores, is precisely the same as that already described for the copper ores; the sulphur being allowed to go to waste. Similar improvements suggest themselves as advisable; though as the metal is so much cheaper, and the process of reduction so much more facile, they do not appear to be so imperiously called for, as an amelioration of the system of working the copper. A singular fact is, that the ore and reduced metal sell, by weight, for the same price at *Kálsi*, the nearest town. I could not learn the reason of this; but suppose that the produce of sulphur, pays the expence of reducing the ore.

XVI.

TABLES.

EXHIBITING A DAILY REGISTER

OF THE

TIDES IN THE RIVER HOOGLY,

AT CALCUTTA,

FROM 1805 TO 1828;

WITH OBSERVATIONS ON THE RESULTS THUS OBTAINED.

By JAMES KYD, Esq.

HAVING kept a Register of the day and night tides in the Hoogly, at Kidderpore, near Calcutta, since the year 1806, for which the nature of my business, and my establishment afforded me facilities, and the permanency of my gage fixed at the dock head, rendering the results correct, beyond suspicion or doubt—I am induced to lay them before the Society, trusting that they may prove interesting.

To avoid the dry detail of a daily Register, I have drawn the heights of the tides in maps, shewing the state of the river throughout the year, conveying at a glance, all that is requisite to be known for every useful purpose.

The

The map No. 1, is made for the year 1806-7, and I have upon the same map, traced the tides for the year 1825-26. The phases of the moon in the latter year falling nearly on the same days, and thus enabling me to give two years together, and to shew the variation between them, at a distance of nineteen years.

Map No. 2, is similar to the first in principle, but has been chosen to shew three distinct inundations, that took place in the year 1823. The first of which was occasioned by the sea, and the second and third by the *Ganges* and *Damoda* rivers. The first was a very rare occurrence, happening not oftener, perhaps, than once in a century; the last nearly as rare, but the second occurs every sixth or seventh year.

Map No. 3, consisting of twelve parts, one for each month, is a daily and nightly record of the river, for the said remarkable year 1822-23.

Map No. 4, gives a comparison of the range of high, and low water for successive years, from 1806 to 1827.

These tide-tables, formed from a register kept for twenty-two years, establish, beyond dispute, the lowest fall and the highest rise of the Hoogly, and thus form natural points for the construction of a River Gage, for the purpose of obtaining, at all times, the levels that may be required for the formation of canals, docks, wharfs, and drains. They also shew the height of the river at all times of the year, a matter of considerable importance in the formation of public works, especially as the variation is so great, at its different periods.

I shall now advert to the local causes which affect the tides in the Hoogly. The maps commence with March, in the beginning of which
the

the south-west monsoon sets in. With the south-west winds, the currents set up the Bay of Bengal, and gradually raise the sea, at its head, several feet, raising with it the Hoogly, long ere the freshes are felt. The dotted curve line in map No. 1, will shew this rising of the sea, and river by the wind, and currents. This cause continues till October; the pouring of the rivers into the Bay of Bengal, during the months of August and September, and the change of wind at the end of October, give the currents a set in the contrary direction, and gradually restore the sea and the river to the state they were in, in March.

The effect of the two monsoons upon the currents, and the height of the sea, in the Bay of Bengal may, therefore, be considered as that of two long unequal tides, during the year, eight months of flood, and four months of ebb.

In conformity with these periodical local causes—partial ones have a corresponding effect, thus strong southerly winds raise the tides, in the Hoogly, whilst northerly ones depress them.

The freshes, or floods of the rivers, are a prominent periodical local cause, operating upon the tides of the Hoogly at Calcutta.

The Ganges begins to rise from the melting of the snow, as early as the beginning of May, but its rising does not sensibly affect the Hoogly till the beginning of July, at that period, so large an accession of water is thrown into the Hoogly, that its level is bodily raised both at high and low water. The last is so remarkable, that the low water of the freshes (neap tides) is higher than the high water (neap tides also) of the dry season, by several feet.

The *Damoda* and western small rivers, or mountain streams, contribute very materially to the swelling of the Hoogly, and it is, probably, the influence of the *Damoda*, the *Ráputrain*, the *Touzoraucolly*, the *Hid-gelee*, and even the *Balasore* river, (the latter situated beyond the mouth of the Hoogly,) that occasions the height of the low water, by their acting as a dam, and preventing the ebbing of the waters from the Ganges, and higher streams, quickly into the sea.

There is another local affection of the tides, the cause of which I cannot satisfactorily explain. In the north-east monsoon, the night tides are the highest, whilst in the south-west monsoon, the day tides are the highest.

A conjecture may be hazarded that as, in both monsoons, the wind is generally higher during the day than in the night, that the wind in the south-west monsoon raises the day tide; whilst in the north-east monsoon the wind, during the day, withholds and depresses the day tide; but this is not entirely satisfactory, in as much as the wind cannot possibly be uniform, whereas the fact of the higher tides during the day in one monsoon, and during the night in the other, is beyond doubt; besides, the latter is very much more than the former, being as much as two feet, whereas the former is seldom more than one foot. The night tides in the north-east monsoon are also more uniform in this respect, than the day tides, in the south-west monsoon.

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Should it appear from future observation that the wind be the cause, it will prove that the depressing effect of the northerly wind, has much more influence upon the tides, than the increase by the southerly ones; or it may be, that the absence of the wind leaves the tide more freedom to act.

I come

I come now to general causes.

The horizontal parallax of the moon invariably affects the tides ; when that is high the tides are high, and vice versa, to such a degree of correctness, that allowing for local causes, I could venture to construct a table for a year in advance, that should not vary two inches, from the actual tides.

When the parallax is highest, on the second, or third day, after the full or change of the moon, the highest tide will correspond with these days, as that is the natural period of its greatest height ; should the parallax be decreasing, the highest tide will be on the day of the full, or change ; and should the parallax be decreasing, and near to its lowest, and increase again, after the natural period has passed, the highest tide will be on the fourth day, after the full or change, of the moon.

The difference of effect between the high or low parallax of the moon, upon the height of the tides, is about two feet, frequently much more ; and as its variation, as to the time, is shown to be four days, this is of importance to all mariners, as enabling them, in cases of danger, to ascertain by their Nautical Ephemeris, the true state of the tides. No longer need they trust to the partial observation and equally partial theory founded thereon of Pilots and seamen. most of whom have a notion that the dark spring tides are always the highest, that the night tides are higher than the day tides, and that the highest tide must always occur on the second or third day after the full, or change, whereas the parallax of the moon will effectually supercede this uncertainty, and either warn a mariner with his bark on a shoal not to wait till the second day, and lose the springs, or save him from despair, because these days may have passed, and induce him to wait with confidence till the fourth day, after the full, or change, for the highest tide, as the case may be.

The parallax of the moon will assuredly indicate the height of the tides all over the world; this general cause, therefore, must be applicable at all places.

The following abstract will be useful, as conveying a general summary of the tides, of the Hoogly.

From the point of lowest low water in the dry season, to that of the highest high water in the freshes, is twenty feet ten inches.

The greatest mean rise of tide from low to high water mark, takes place in March, April, and May, and is fifteen feet ten inches.

The greatest mean rise of tide from low, to high water mark, in the freshes, is ten feet.

The smallest mean rise of tide takes place in the freshes, and is at neap tides, only three feet six inches.

The smallest mean rise of the tide in the dry season, neap tides, is four feet.

From the lowest fall of the river, to high water mark, neap tides, in February, is eight feet.



From the lowest fall of the river to low water, in the freshes (neap tides,) is twelve feet.*

The

* During the inundation in September, 1823, the low water stood at eighteen feet six inches, the tide having ebbed only fifteen inches on that day. The difference between this low water, and the high water (neap tides in February; viz. eight feet,) is ten feet six inches!!

The river is at its lowest, in the beginning of March.

The river is swollen by the freshes in July, August, and September, and part of October.

The freshes take off about the middle of September, and are generally out of the river, by the end of October.

At the beginning of November, although the freshes are out of the river, it is upwards of three feet higher at low water, than in March.

The river is in the most quiescent state, during the months of November, December, January, and February; during these months the night tides are higher, and more rapid than the day tides, and there are, on some occasions, bores at night.

The strongest flood tides, and the greatest mean rise of the tides, are in March, April, May, and June. The day tides in these months, are higher, than the night tides.

The strongest freshes are in September.

In July, the strength of the flood tides is counteracted by the freshes, and this, therefore, is a moderate month, as regards tides. The bores also are moderated as a consequence.

In August, the flood tides are overcome by the freshes, and the bores are moderate; should there be a high parallax of the moon, however, the great height of the sea, in this month, will cause a considerable bore.

In September, the freshes are at their height, there is no visible tide off Calcutta, the ships do not swing up, and the river water is perfectly sweet, far beyond Saugor in the open sea. The high parallax of the moon at the equinoxes, with the great height of the sea, produces a heavy bore in this month.

The Bores.

The bores in the Hoogly occur only on the highest, or at alternate spring tides; their appearance may, with certainty, be predicted by the season of the year, and the parallax of the moon. During the months of November, December, January, and February, or on the periodical ebb of the sea, when the currents are setting down the Bay, the tides, as may be supposed, are languid, and consequently, during this period, there are no bores.*

As soon as the south-west monsoon sets the currents up the Bay, the sea begins to rise, the tides become strong and high, and bores follow in their train; whenever the parallax of the moon is high on the springs during the south-west monsoon, bores will certainly make their appearance, and when strong southerly winds are added, and freshes withheld, the height of the bores will be increased.

It

* Except very rarely.—In twenty-two years I have known but three instances. Agreeably to the Statement of local causes which accelerate or depress the tides, it will be obvious that during the north-east monsoon, if the winds which blow the waters down the Bay, be more than usually moderate, and the moon's parallax be high, there may be a high tide, and with it a bore, and this, agreeably to the third local cause, will happen at night. These night bores are particularly dangerous, as they are very rare and, consequently, unexpected. They may be guarded against, by always considering it possible for them to occur during the north-east monsoon at night, upon a high parallax of the moon. Agreeably to the same local cause, it is fortunate that the bores at night, during the south-west monsoon, are not so high, as in the day.

It must be remembered that the height of the bore, is actuated by the peculiar form of the sands, and the direction, and set of the tides, in any particular reach of the river ; for instance, where the channel is straight, with deep water, from side to side, and no sand-bank, there will be no bore at any time ; but a mere swell on the coming in of the tide. This is the case at the lower part of Garden Reach, opposite the Botanic Garden. This is the case also off Calcutta, at Howrah Ghaut, where the back channel having lately filled up, the main channel is now confined between high banks. It is only where the main channel lies on one side, with a low sand on the other, that the bore shews itself upon the latter. This, a very few years ago, was the case opposite to Calcutta, and there was, at that time, an enormous bore, but which, as above explained, exists no longer.

END OF PART I.

APPENDIX.

No. I.

List of the Donors and Donations to the Physical Committee of the Asiatic Society, from 11th February 1828, to 20th May, 1829.

J. ADAM, ESQ.—Three well-preserved Specimens of the Mantis Insect.

MAJOR BEATSON.—Some Specimens of the prevailing Rocks about Simlah.

CAPT. W. BRUCE,—A Bottle of Hot Water from the Hot Springs at the foot of the Attaram Hills, in the Province of Tenasseram.

Some Mineral Specimens from Persia, the Coast and Islands of the Gulf of Persia, and also some from the Coast of Tenasseram. Some Minerals collected in a Journey along the Hills of Rotas Ghur and Sasseram.

J. CALDER, ESQ.—A Series of Specimens illustrative of the Secondary Rocks, containing Organic Remains from the neighbourhood of the Giants' Causeway in Ireland; and also a Specimen of two very perfect Joints from one of the Basaltic Columns of the Causeway. A singular Species of Mollusca, from the Coast of Ceylon.

CAPT. COULTHARD.—A Series of Specimens from Saugor, and its adjoining Districts.

DR. DUNCAN.—Some Fossil Bones of an Elephant, found in the river near Culpee.

LIEUT. J. FINNIS.—Specimens of the Minerals in and near the Coal Mine at Hassinhabad.

CAPT. JAS. FRANKLIN.—An extensive Series of Geological Specimens from Bundelcund, Boghelcund, and the Districts of Saugor and Jubbulpore.

- DR. GOVAN.**—First and Second Selections of Specimens from the vicinity of Simlah. A third Selection of Specimens from the Himalaya range. Some Organic Remains from the bed of the Sutlege. Additional Specimens from the Hill Provinces.
- DR. J. GRIERSON.**—A well-preserved Specimen of the Long Ear'd Bat (*Nospertilio Auritus*).
- J. HARDIE, Esq.**—Some Specimens of the Rocks near Biana. Mineral Specimens from Central India.
- COL. HODGSON.**—A Geological Map of England.
- MR. LESLIE.**—Drawings of a Doe and of its Skull.
- MR. LEWIS.**—Some Specimens of Rock (granite) and Earth from the top of Mount Ophir, Malacca.
- R. ROSE, Esq.**—A Collection of Geological Specimens made during a Survey of the Roads from Midnapore to Sumbulpore, and from thence to Cuttack and Balasore.
- DR. ROYLE.**—A Series of Specimens illustrative of the Districts of Rajpore, Mussooree, &c.
- MR. SMITH.**—Specimens of Lithographic Printing from Captain Franklin's Lias Limestone of Bundelcud. Specimens of Lithographic Printing from Stones sent down from Agra by Lieutenant J. F. Boileau. An Impression from a Rotus Stone, sent by Lieutenant J. Thomson.
- DR. P. F. STRONG.**—Specimens of Peat Earth from a large Tank on the Dum Dum Road. Specimens of the Clay obtained in repeated borings in and near the Salt Water Lakes, Calcutta.
- LIEUT. J. THOMSON.**—A Series of Specimens from the vicinity of Gyah and Rotus Gurh.
- MR. WALTERS.**—A Box of Minerals from the Cossiah Hills.
- MR. WAND.**—Specimens of the Calcareous Deposit found about the Hot Spring in Bencoolen.
-

No. II.

INSTRUCTIONS FOR COLLECTING GEOLOGICAL SPECIMENS.*

IT so often happens that specimens sent from distant places, by persons unpractised in geology fail to give the instruction which is intended, from the want of attention to a few necessary precautions, that the following directions may perhaps be useful to some of those, into whose hands these pages are likely to fall. It will be sufficient to premise, that two of the principal objects of geological inquiry, are, to determine, —1st, the nature of the *materials* of which the earth is composed; and, 2ndly, the relative *Order* in which these materials are disposed with respect to each other.

1. Specimens of rocks ought not, in general, to be taken from loose pieces, but from large masses in their native place, or which have recently fallen from their natural situation.

2. The specimens should consist of the stone unchanged by exposure to the elements, which sometimes alter the characters to a considerable distance from the surface.—Petrifactions, however are often best distinguishable in masses somewhat decomposed; and are thus even rendered visible, in many cases, where no trace of any organized body can be discerned in the recent fracture.

3. The specimens ought not to be too small.—A convenient size is about three inches square, and about three-quarters of an inch, or less, in thickness.

4. It seldom happens that large masses, even of the same kind of rock, are uniform throughout any considerable space; so that the general character is collected, by geologists who examine rocks in their native places, from the average of an extensive surface:—a collection ought therefore to furnish specimens of the most characteristic varieties;—and *the most splendid specimens are, in general, not the most instructive*. Where several specimens are taken from the same place, a series of numbers should be added to the note of their locality.

* From the Appendix to Captain P. P. King's "Narrative of a Survey of the Inter-tropical and Western Coast of Australia;" by William Henry Fitton, M.D., F.R.S., V.P.G.S.

5. One of the most advantageous situations for obtaining specimens, and examining the relations of rocks, is in the sections afforded by cliffs on the sea shore ; especially after recent falls of large masses. It commonly happens that the beds thus exposed are more or less inclined ; and in this case, if any of them be inaccessible at a particular point, the decline of the strata will frequently enable the collector to supply himself with the specimens he wishes for, within a short distance. Thus, in the subjoined sketch, which may be supposed to represent a cliff of considerable height,—the observer being situated at *a*, the beds *b*, *c*, *d*, though inaccessible at that place, may be examined with ease and security, where they successively come down to the shore at *b'*, *c'*, and *d'*.



6. To examine the *interior* of an unknown country, more skill and practice are required : the rocks being generally concealed by the soil, accumulations of sand, gravel, &c., and by the vegetation of the surface. But the strata are commonly disclosed in the sides of ravines,—in the beds of rivers and mountain-streams ; and these, especially where they cross the direction of the strata, may be made, by careful examination, to afford instructive sections.

7. Among the occasional components of the strata, the remains of organized bodies,—shells, corals, and other zoophytes,—the bones and teeth of animals,—fossile wood, and the impressions of vegetable stems, roots, or leaves, &c., are of the greatest importance ; affording generally the most marked characters of the beds in which they occur.—These should, therefore, be particularly sought after, and their relative abundance or rarity in different situations noticed. The petrified bodies should, if possible, be kept united with portions of the rock or matrix in which they are found ; and where they are numerous,—in sand, clay, or any moist or friable matrix,—it is in general better to retain a large portion of the whole mass, to be examined afterwards, than to attempt their separation at the time of collecting.

8. The *loose materials* which are found above the solid rocks, in the form of gravel, silt, rolled pebbles, &c., should be carefully distinguished from the *solid strata* upon which they rest. And the more ancient of these loose materials, found on the sides or summits of hills, &c., should be distinguished from the recent mud, sand, and gravel, brought down by land-floods, or by rivers. The bones and teeth of animals are not unfrequently found in the more ancient gravel ; and the collection of these remains from distant quarters of the globe, is an object of the greatest interest to geology.

9. Besides a note of the locality, there ought, if possible, to accompany every specimen, a short notice of its geological circumstances ; as—

Whether it be found in large shapeless masses, or in strata ?

APPENDIX.

If in strata,—what are the thickness, inclination to the horizon, and direction with respect to the compass, of the beds?—[If these cannot be measured, an *estimate* should always be recorded, while the objects are in view.]—Are they uniform in dip and direction?—curved, or contorted?—continuous, or interrupted by fissures or veins?

Is the whole cliff, or mass of strata in sight, of uniform composition?—or does it consist of different kinds of stone?

If the strata be different,—what is the order in which they are placed above each other successively?

10. A *label*, distinctly written, should accompany every specimen, stating its native place, its relative situation, &c. &c. And these labels should be connected with the specimens immediately, on the spot where they are found*.—This injunction may appear to be superfluous; but so much valuable information has been lost to geology from the neglect of it, that every observer of experience will acknowledge its necessity; and it is, perhaps, in practice one of the most difficult to adhere to.

11. A *sketch* of a coast or cliff, however slight, frequently conveys more information respecting the disposition and relations of rocks, than a long memorandum. If numbers, denoting the situation of the specimens collected, be marked upon such sketches, much time may be saved at the moment of collecting. But in all such cases, the memorandum should be looked over soon afterwards, and labels distinctly explaining their situation, &c., be attached to the specimens themselves.

12. The specimens should be so packed, that the surfaces may be defended from exposure to air, moisture, and friction: for which purpose, if strong paper cannot be obtained, dry moss,† or straw, or leaves, may be employed.‡ Where paper is used for wrapping the specimens, they are best secured by fastening the envelope with sealing-wax.

Lastly, The collector must not be discouraged, nor be prevented from collecting, by finding that the place which he may chance to visit in a remote situation, has not a striking appearance, or the rocks within his view a very interesting character; since it frequently, and even commonly, happens, that facts and specimens, in themselves of very little importance, become valuable by subsequent comparison; so that scarcely any observation, if recorded with accuracy, will be thrown away.

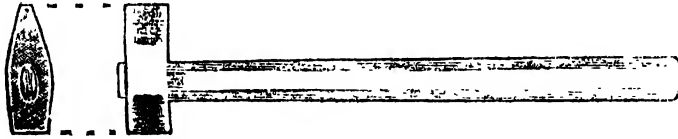
* It is useful to mark on the labels the day, and even the hour, when each specimen is collected. This, with a corresponding note in the memorandum-book, will be found to assist the memory, and prevent confusion. Besides the label attached to the specimen, it is a very necessary precaution in India, to describe the locality, &c., of the specimen on a separate slip of paper, to be well doubled up and enclosed in the same wrapper with the specimen.

† Cotton, wool, or sunn.

‡ Kalajeera seeds, or pounded spices, should be scattered amongst the parcels to preserve the labels and wrappers from insects.

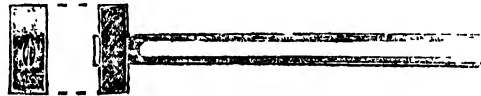
The *Instruments* required by the geological traveller will vary, according to the acquirements and specific objects of the individual. The most essential are :—

The *Hammer* ; which, for general purposes, may be of the form here represented :—



The head should be of steel well tempered, about 4 inches from the face to the edge, and $1\frac{1}{4}$ inch square in the middle ; the face flat, and square, or nearly so ; the edge placed in the direction of the handle. The orifice for the insertion of the handle oval, a very little wider on the outer side than within ; its diameters, about 1 inch vertically, and $\frac{7}{10}$ across ; the centre somewhat more than $1\frac{1}{2}$ inch from the face. The handle should be of ash, or other tough wood ; not less than 16 inches long ; fitting tight into the head at its insertion, without a shoulder ; and increasing a little in size towards the end remote from the head, to prevent its slipping.—It should be fixed in the head by means of a thin, barbed iron wedge.

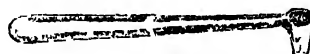
For *trimming* specimens, smaller hammers may be employed :—The form of the head, recommended for this purpose by Dr. MacCulloch*, is rectangular. The dimensions of the face may be 1 inch by $\frac{3}{4}$; the height $2\frac{1}{4}$.



It will be expedient to have always some hammers, (or at least the heads,) of different sizes, in reserve.

A small *miner's pick* is useful for cutting out, and splitting portions of slaty rocks ; or for obtaining specimens of clays, &c.

A small *stone-cutter's chisel*.—A chisel with a handle, of the form here represented, will often save the hand of an inexperienced collector, and better enable him to direct his blow.



* On the forms of *Mineralogical Hammers*." Quarterly Journal, (R. Inst.) vol. xi. 1821, p. 1, &c.

For *Packing the specimens*.—A stock of *strong paper**, *Sealing-wax*. *Writing-paper*, cut into *labels*. Thick *gum-water*, to cement the *labels* to the *specimens*†.

For the *Conveyance of specimens*.—A large *bag of leather*, with *straps* for the *shoulders*. Strong *canvas bags*, of *smaller size*, are very convenient for *subdivision and arrangement*.—For the *protection of crystals*, or *delicate petrifications*, &c., *wool* or *cotton* are necessary; and *small wooden boxes* (like those used for holding *wafers*) are sometimes required. For *distant carriage*, *strong wooden boxes*, *casks*, or *baskets*.

The following are either *essential*, or *useful* in various *degrees*, for *obtaining and recording observations*.

Pocket Memorandum-Books, of sufficient size to admit *sketches*.

A Pocket Compass.

A Measuring-tape, of fifty feet, or more.

A Telescope.

A Camera Lucida.

A Box of Colours.

The best *Maps* should always be sought for:—And, the true *economy* to the *traveller* being that which saves *time*, it is best to *mark*, or even to *colour* the *map*, in the *field*. Notes inserted on *imperfect maps*, or *deduced afterwards* from *memoranda*, are *less authentic*; and the *process* is frequently *neglected*.

Portable-Barometers, with *detached thermometers*, are *desirable*; and the best *instruments* are ultimately the *cheapest*. But, unfortunately, *barometers* of every *construction* are very *easily damaged* or *deranged*.—Minute *accuracy*, however, in the *determination of heights*, though very *interesting* to *physical geography*, is comparatively of *little importance* to the *geologist*.

If the *collector* be a *surveyor*, he will know best to what purposes a *Pocket Sextant*, or a *small Theodolite*, is applicable:—the *measurement of distances*,—of *heights*,—and of the *inclination of strata*, &c.

* Strong English brown paper is preferable to any other as no insects will attack it.

† If paste is used, any essence added to it will preserve it from mildewing.

ERRATA

In Paper IX by H. Piddington, Esq.

Page 171, last line but one, for "shaggy," *read* *slaggy*.

" " the last line, for "or charcoal," *read* *on charcoal, &c.*

" 172, sixth line from the bottom, for "Lime, with a trace Mag." *read* *Lime, with a trace Magnesia.*

" " two lines lower down, for "5950 Iron" *read* *59-50, &c.*

" 173, tenth line from the top, for "Lime Phosphate Iron" *read* *Lime and Phosphate Iron.*

ASIATIC RESEARCHES.

TRANSACTIONS

OF THE

PHYSICAL CLASS

OF THE

ASIATIC SOCIETY OF BENGAL.

PART II.

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1833.

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I.

OBSERVATIONS ON THE INCLINATION AND DECLINATION OF THE MAGNETIC NEEDLE.

BY LIEUTENANT COLONEL J. A. HODGSON,

Surveyor General of India; and

MONSIEUR DE BLOSSVILLE,

Honorary Member Asiatic Society.

Communicated by Captain J. D. HERBERT, Assistant to the Surveyor General.

THE progress which has latterly been made in the investigation of the magnetic phenomena is remarkable. A new science, that of Electro-magnetism, has been created, and the happy conjecture hazarded by PLAYFAIR, that the mysterious properties or powers of matter, which we name gravity, chemical affinity, galvanism, magnetism, electricity, &c. would be one day referred to a single cause, has been almost realized. The very striking facts developed in the thermo-electric experiments have been ably investigated, while the law of the magnetic force has been determined, and the effect of local attraction rigorously calculated. The

curious practical result of these latter investigations leading to the correction of that disturbance, under which the magnetic needle on board ship had till then laboured, from the influence of the iron-work about the vessel—offers an example of that utility which, though it may not always be obvious, yet is assuredly sooner or later the fruit of an assiduous cultivation of science.

Nor have the more ordinary phenomena of magnetism been neglected in this general movement. An immense mass of results have been collected by our voyagers to the north pole, relating to the declination and inclination of the magnetic needle, as well as the intensity or directive power. Other observers have assisted, and as far as Europe and the northern regions are concerned, little, perhaps, remains to be desired in this branch of experimental Physics. But with regard to the other countries of the globe, the facts that have been collected are “few and far between.” I am happy, therefore, to be able to communicate the following observations made in this country by two members of this Society. We have not yet had any observations of the kind recorded in India, and I doubt not the Society will receive favorably this attempt to fill up the blank that exists. Let us hope, too, that the publication of these results may stimulate other enquirers; and that, by their exertions, we shall yet have correct determinations of the three elements of magnetic inclination, declination, and intensity, at all the principal places of our Indian empire.

The results now offered comprehend the determination of the declination and inclination of the magnetic needle. The first series made on board the French Corvette *La Chevette*, is by M. DE BLOSSVILLE. I have not thought it necessary to translate his introductory notice, as preferring to retain his own expressions.

“Les observations que j’ai faites dans les differens lieux on *La*

Chevrette a touché comprennent tous les elemens du magnetisme terrestre ; mais l'étude des plusieurs de ces phénomènes ne pourront fournir des résultats positifs, qu'après avoir repeté a l'observatoire royal de Paris, les épreuves des instrumens qui ont été employés : il ne sera question dans cette notice que de l'inclinaison, et de la declinaison de l'aiguille aimantée. Ce n'est également qu'après le retour de la Corvette, qu'on pourra s'occuper de tirer des conclusions des observations météorologiques qui ont été faites d'heure en heure avec des barometres et des thermometres tres exacts, pendant toute la durée du voyage."

"L'inclinaison de l'aiguille a été mesurée avec une boussole et quatre aiguilles qui furent mises pour la premiere fois en expérience a l'Observatoire de Paris, en presence et sous la direction de M. Arago, membre de l'Institut, quelques jours avant notre départ. Dans cette occasion, comme dans toutes les autres, lorsqu'une aiguille a été observée sur ses deux faces ; on a changé ses poles avec de forts carreaux et après avoir obtenu une seconde inclinaison, on a eu, en prenant la moyenne des deux, un résultat exempt des erreurs qu'aurait pu produire un défaut d'équilibre. Pour placer l'aiguille dans la direction meridienne magnetique on a cherché d'abord le plan perpendiculaire, ou le plan de l'équateur dans lequel elle se trouve verticale, ou bien, dans les faibles latitudes, on a orienté la boussole d'après une mire bien déterminée. Quelque fois ces deux methodes ont été employées concurremment et ont offert l'accord le plus parfait. On trouve dans le tableau le résultat moyen des quatre aiguilles."

"Une description de la boussole declinatoire qui nous avait été fournie par *Le depot des cartes et plans de la marine*, serait trop longue, mais les personnes qui l'ont vue a Calcutta se sont convaincus de l'exactitude de cet instrument, et de tous les moyens de verification qu'il reunissait. Dans toutes les experiences on s'est servi de deux aiguilles qu'on retournait sur leurs chapes au milieu des observations et dont on n'a pas renouvelé

le magnetisme pendant toute la durée du voyage. Les deux aiguilles n'ont jamais differé de plus d'une minute dans le relevement des mires dont la position astronomique a toujours été déterminée au moyen d'une circle de reflexion de Borda, par des series nombreuses d'azimuths pris a l'est et a l'ouest."

I.—TABLEAU DES INCLINAISONS ET DECLINAISONS.

NOMS DES LIEUX.	DECLINAISON.	INCLINAISON.
Paris,	22° 24' 41" N. O.	67° 51' 42" N.
Toulon,	19 21 23 N. O.	63 14 0 N.
St. Denis-Ile Bourbon,	11 57 48 N. O.	55 05 51 S.
Calcutta,	2 38 05 N. E.	26 32 38 N.
Chandernagor,	2 39 52 N. E.	26 47 03 N.
Rangoun,*	0 49 52 N. E.	17 51 47 N.
Tringuemalay,	1 08 05 N. E.	3 34 10 S.
Jaffnapatam,	1 16 00 N. E.	0 39 45 S.
Souliperon, Ceylon,	" " "	0 36 34 S.
Aripo, Ceylon,	" " "	2 17 34 S.
Batavia,	0 31 08 N. E.	25 50 01 S.
Pondicherry,	1 02 13 N. E.	3 46 00 N.
Karikal,	1 14 01 N. E.	" " "

* Les observations de Rangoun ont été faites par le Capt. Fabré et M. Jeanneret.

This Table is an important addition to our knowledge of the magnetic phenomena. The magnetic equator, it appears, passes at no great distance north of the island of Ceylon, and touches the northern extremity of the island Junkseilon. This would give the place of the magnetic pole, as in lat. 80°, long. W. 105°, being very nearly the position assigned to it by the observations made by Captain PARRY and his associates*. It does not, however, appear that the magnetic equator must

* First Voyage. Captain SABINE gives the position as being 60° N. Lat. and 90° W. Long.

necessarily be a great circle of the sphere, or the magnetic pole a mathematical point.

The next Table contains the details of some magnetical observations made at the observatory of the Surveyor General's Office, under the direction of Lieutenant-Colonel HOBGSON. There being no inclination instrument, or dipping needle, in the dépôt, the investigation was necessarily confined to the determination of the declination. The paper gives all the particulars, and details the precautions taken to insure a correct result. One verification which is not touched on in either of the papers I may notice, as it is an important one, and is seldom adverted to.

In making observations with a declination circle—the following is the proceeding. The true azimuth of an object, or its angular distance from the meridian, being determined by other methods, we observe its magnetic bearing by the declination instrument, that is, the angle which the object forms with the direction of the needle. Now this supposes that we can determine the precise point on the limb of the instrument situated in the vertical plane, passing through the line of collimation of the telescope, and also in that passing through the axis of the needle. The first can be done by reversing the telescope, and repeating the intersection of the object, taking the mean of the two readings as the true place of the telescope on the limb. But the second has this difficulty attending it as these instruments are ordinarily made, that the needle being referred to a different set of divisions, unless we are sure that the line marked zero on each accurately correspond, there will be error. This is a point the verification of which is not provided for by any instrument I have seen, although the remedy is obvious enough—that of making the same set of divisions answer for both needle and telescope. This I have understood was the case in M. DE BLOSSVILLE's instrument. To determine the amount of the error, if any, in the instrument used at the Surveyor General's Office, I proceeded as follows :—

A theodolite was set up, and the telescope directed to the declination instrument, which was placed as nearly as could be estimated, so that its plane should be at right angles to the axis of the telescope. The telescope being then made to pass through the 0° and the 180° divisions of the exterior limb was found to form an angle with the line of north and south in the compass-box, the wire of the telescope passing to the west of the north end, and to the east of the south end.

It was not easy so to adjust the two instruments that the line described by the cross wires should exactly fall on both 0° and 180° . It was, in fact, found that more satisfactory results were obtained by bringing them on the upper point or 0° by means of the tangent screw, and then estimating the deviation on each of the other three points. As the telescope has a considerable magnifying power, and as the declination circle was within five feet, such an estimate it was found could be performed with tolerable accuracy. To make this clearer, I shall give the detail of one observation :

Cross wires of telescope, on 0° . $0'$ of outer circle.

passes to West of North, .. 0 . 30 inner circle.

———— East of South, .. 0 . 12 inner circle.

———— East of 180° 0 . 10 outer circle.

Here then it is evident, that the cross wires of the telescope, described a line forming an angle of $\frac{0 + 10'}{2} = 5'$, with the line joining 0° and 180° on the outer circle. While it formed an angle of $\frac{30' + 12'}{2} = 21'$, with the line of north and south in the compass-box. Consequently, the latter must have formed an angle with the former of $16'$, and by that quantity must the declinations determined by this instrument be erroneous. A second observation gave $15\frac{1}{2}$, a third $13\frac{1}{2}$, a fourth $12\frac{1}{2}$,—mean $14' 4''$.

To understand whether this correction be $+$ or $-$ we are to consider 1st. That, the line joining 0° and 180° on the limb, (north end) passed to the east of the line described by the cross wires; 2nd. That the line of north and south in the compass-box (north end) also passed to east, but by a greater quantity. Then the north and south line in the compass-box passed (north end) to east of the line joining 0° and 180° on the outer limb. The point to which the needle should have been adjusted is, consequently, $14' 24''$ west of the point to which it is actually adjusted. Now, let us suppose the magnetic bearing of the meridian taken, it will be $2^\circ 26' 52''$ north-east; but if the point from which the divisions are reckoned, and with it each of the divisions were moved $14' 24''$ west, then the above bearing would be $14' 24''$ more. Adding this quantity to $2^\circ 26' 52''$ we get $2^\circ 41' 16''$ as the correct declination in Calcutta, in February 1828. It is worthy of remark, that M. DE BLOSSVILLE's determination (see Table I.) is $2^\circ 38'$, being only $3' 16''$ less. His instrument did not require this correction, as the needle and telescope were referred to the same set of divisions. Whether the circumstance of its having no nonius for reading the sub-divisions will account for the above small difference of $3' 16''$, I cannot pretend to say. It is to be observed, that even with the *same observer and instrument*, the latter furnished with three nonii, two different needles may vary $2' 24''$.

To this cause I am disposed to attribute the discrepancies observable in taking magnetic bearings with different theodolites, which I have found sometimes amounted to $1^\circ 36'$. When the magnetic declination is observed with the same theodolite with which the bearings were observed, this becomes a matter of no moment, but it must always be an obstacle in determining the absolute amount of the magnetic declination. For this reason I think no great stress can be laid on the contents of Table III. compiled by Lieutenant Colonel HODGSON, which I, nevertheless, give, as it may attract the attention of the several observers to the subject, and induce them, perhaps, to verify their results in the manner indicated.

Memorandum of Observations made at the Observatory, Surveyor General's Office, Chowringhee, Calcutta, to determine the Magnetic Declination between the 3d February and 24th February, 1828.

“ The Declination instrument is made by GILBERT ; the azimuth circle is of eight inches diameter, and divided to 30' subdividing to single minutes ; the divisions are read by three verniers, at equal distances, and each observation below noted is the result of twelve readings ; i. e., three with the face of the altitude circle to the east, and three to the west, from the north end of the needle, and of as many from the south end. The telescope is of $11\frac{1}{2}$ inches focal length, and $1\frac{3}{8}$ inch aperture, and carries cross wires.

The instrument being placed on a stone pillar at a convenient distance from the transit instrument in the Observatory, out of the influence of iron, and duly adjusted, was correctly laid on the distant meridian mark by causing its centre wire to cover the distant meridian mark, and also the centre wires in the transit telescope, the wire of the declination instrument being reciprocally viewed and covered by the meridian wire of the transit telescope.”

The result derived from three Needles, are as follow :

TABLE II.

Date. 1828.		Time.	Barometer by Troughton.	Attached Thermometer.	Detached Thermometer.	Declination East of the North end of the Needle.	Declination West of the South end of the Needle.	Mean Declination East.
February	3	H. M.	Inches.					
		0 40 P. M.				2° 35' 50"	2° 27' 30"	
	4	05 30 P. M.				2 22 00	2 23 50	
		09 20 A. M.	29.960	67°	70°	2 25 40	2 28 50	
		00 35 P. M.	29.930	78	79	2 21 00	2 26 20	
		5 15 P. M.	29.864	80	82	2 22 10	2 21 20	
	5	8 55 A. M.	29.962	69	70	2 27 50	2 28 30	
		0 25 P. M.	29.954	77.7	80	2 21 50	2 23 40	
		5 25 P. M.	29.888	80	82	2 22 00	2 28 30	

OF THE MAGNETIC NEEDLE.

9

Date. 1828.		Time.	Barometer by Troughton.	Attached Thermometer.	Detached Thermometer.	Declination East of the North end of the Needle.	Declination West of the South end of the Needle.	Mean Declination East.
February.	6	11. M.	Inches.	°	°			By Needle No. 1. 2° 25' 22"
		8 55 A. M.	30.032	66	69	2° 25' 50"	2° 30' 40"	
		0 29 P. M.	30.020	76.5	79	2 21 30	2 26 40	
	7	5 00 P. M.	29.968	82		2 25 30	2 23 00	
		8 27 A. M.	30.028	67.5	68	2 22 40	2 28 10	
		0 52 P. M.	30.012	71	77	2 21 40	2 27 20	
	8	4 40 P. M.	29.970	78	80	2 26 20	2 25 30	
		7 35 A. M.	30.032	58.5	61	2 23 40	2 26 30	
		0 30 P. M.	30.600	73	76	2 25 00	2 25 00	
	9	5 10 P. M.	30.010	75	78	2 19 00	2 27 50	
		0 18 A. M.	30.100	65.5	67	2 23 00	2 30 00	
		0 08 P. M.	30.050	73.5	76	2 23 30	2 26 50	
	10	9 10 A. M.	30.054	63	61	2 21 20	2 23 10	
		1 00 P. M.	30.018	72.5	76	2 21 40	2 27 00	
		5 00 P. M.	29.976	73	74	2 25 00	2 30 40	
	11	9 00 A. M.				2 21 50	2 25 00	
		15 15 P. M.	29.970	78	79	2 22 10	2 25 20	
		8 40 A. M.	30.088	63	61	2 35 10	2 27 10	
	12	0 36 P. M.	30.072	75	77	2 33 30	2 26 20	
		5 12 P. M.	29.988	78	79.5	2 25 50	2 24 30	
		8 15 A. M.	30.088	64	65.5	2 31 10	2 25 30	By Needle No. 2. 2° 27' 46"
	13	0 50 P. M.	30.080	77	79	2 27 10	2 26 10	
		5 12 P. M.	30.048	79.5	80.5	2 31 20	2 29 30	
	14	9 00 A. M.	30.060	63	65	2 26 40	2 26 40	
		11 50 A. M.	30.090	73	75.5	2 29 20	2 23 30	
		1 51 P. M.	29.920	79.5	80.5	2 28 00	2 23 00	
	15	8 02 A. M.	30.016	60	66	2 28 40	2 26 20	
		8 25 A. M.	30.112	66	68	2 23 20	2 29 00	
		0 58 P. M.	00.072	81.5	86	2 25 30	2 23 00	
	16	4 27 P. M.	30.000	90.5	90	2 29 10	2 29 30	
		9 30 A. M.	30.050	73.5	75	2 33 00	2 26 00	By Needle No. 3. 2° 27' 20"
		0 30 P. M.	30.011	83	85	2 29 10	2 20 20	
	17	5 35 P. M.	29.912	89.5	89.5	2 28 30	2 21 30	
		9 30 A. M.	30.030	76.5	77.0	2 20 00	2 26 20	
		9 27 P. M.	29.980	83.5	85.5	2 33 00	2 27 10	
	18	5 42 P. M.	29.926	89.5	80.0	2 27 40	2 27 20	

Mean of Needle, No. 1, 2° 25' 22"

No. 2, 2 27 46

No. 3, 2 27 29

Mean of three Needles, 2 26 52

Add error of Zero in Compass Box, 14 24

Declination East, 2 41 16

“The following are the results of some Observations for determining the Magnetic Variation lately made at places situated at considerable distances from Calcutta, and from each other.”

TABLE III.

Date.			Place.	Province or District.	Latitude.	Observer.	Declination.
Year.	Month.						
1813	March	23	Sukeet,	Dooab,	27° 26' 41". 2 N.	Major Hodgson,	0° 42' 00" East.
	April	11	Berouly,	ditto,	28 5 32		0 41 00
	May	10	Sesanna,	ditto,	28 59 00 2		0 31 30
	June	21	Rhadana,	ditto,	29 13 10		0 33 45
	Nov.	8	Coel,	ditto,	27 53 13		0 59 00
			Sookertal,	ditto,	29 28 49 6		1 06 00
	Dec.	2	Chandy Pahar,	ditto,	29 55 29		0 37 00
			Dehrah,	Doon Valley,	30 19 11		0 18 08 E.
1811	April		Sen-pour,	ditto,	30 23 02		0 28 03
1815	Feb.	8	Bunjary Pokra,	Bettiah,	27 2 29		1 30 13
	May		Distoufia,		26 10 30		1 27 15
1816	March		Scharungoor,	Dooab,	29 57 10		0 51 00
	April	2	Mohun,		30 33 20 75		0 30 00
		25 or 26	Chour Station,	Hill States,	30 50 27 33		0 50 55
	Dec.	14				Goverdhanpoor,		Dooab,	29 11 19	0 40 00
1817	Feb.	2	Kasheepoor,	Rohilkhund,	29 11 55		0 47 15
1825	Nov.	7		Sylhet,		Lieut. Fisher,	2 21 18
							2 36 00
1827	Dec.		Idyanah,	Dehli,	29 21 37	Capt. Oliver,	1 25 00
	Nov.		Calcutta,	Bengal,	22 33 16		Capt. Faber,	2 38 51
			Surveyor General's Office,	ditto,	22 33 00		2 28 36
			Chandernagore,	ditto,	22 50 00		2 39 52
	Dec.	30	Langtofal,	Muncepoor,	24 15 28	Lt. Pemberton,	3 57 09
1823	Feb.	3	Dhoulpoor,	Agra,	26 10 56 5		Capt. Gerard,	1 25 00
			Agra,	ditto,	27 10 29	1 23 00	
		22	Nowagaon,	Scindiah's States,	25 56 30		1 19 03
	March	2	Narwan Fort,	Malwa,	25 38 34		1 01 00
1828	Jan.	21	Kyranah,	Dooab,	29 33 58	Lt. W. Brown,	1 31 13
			Bal,	Dehl,	29 33 00		Capt. Oliver,	1 25 00
			Tajmahul,	Agra,	27 10 20	Capt. Gerard,	1 09 00
			Dhoulpout,	ditto,	26 11 00		1 11 00
			Gwalior Residency,	Scindiah's States,	26 16 00		6 49 00
			Ditto Lieut. De Voens House,	ditto,			1 00 00
			Seronge,	Malwa,	24 06 00		0 57 00
			Bhopaul,	ditto,	23 15 00		0 39 00

As upwards of a year had elapsed since the preceding result had been obtained, I thought it would be interesting to determine again this element, in order to judge what might be the amount, and what the direction of the annual variation if any—Table IV. contains the results of this series of Observations, continued from the 23d May to the 9th June. The Observations were made by the same person, with the same precautions, and using the same instrument as in the preceding year; and therefore we may, I think, receive with every confidence the amount of the variation which for fifteen months appears to be $17' 6''$ west, the declination itself being east, and amounting to $2^{\circ} 41' 16''$ for 1828, and $2^{\circ} 21' 16''$ for 1829. If this rate should continue, we may soon expect the needle to point due north at Calcutta, after which, I suppose, it will continue to move westward, so as to occasion a westerly declination.

Observations of the Magnetic Declination made at the Observatory, Surveyor General's Office, Calcutta.

TABLE IV.

Date.	Hour.	Barometer	Attached Thermometer.	Detached Thermometer	North End of Needle.	South End of Needle.	Mean.
1829, May 23d	H. M.	Inches.	°	°			° ' "
	0 25 P. M.	29.229	95.8	96.0	2 07' 40"	2 08' 30"	2 08 05.0
	4 43	.768	85.5	85.0	2 08 25	2 10 15	2 09 20.0
24th	9 15 A. M.	.862	88.8	88.8	2 08 40	2 12 40	2 10 40.0
	0 15 P. M.	.780	92.8	91.5	2 01 25	2 11 15	2 07 50.0
25th	9 25 A. M.	.770	93.0	90.6	2 06 10	2 10 40	2 08 40.0
	0 15 P. M.	.738	93.8	95.0	2 10 05	2 10 50	2 10 27.5
	1 30	.650	95.0	91.0	2 07 10	2 12 10	2 09 55.0
26th	9 05 A. M.	.710	89.7	90.3	2 12 25	2 14 45	2 13 35.0
	0 30 P. M.	.686	95.0	96.0	2 07 05	2 10 45	2 08 55.0
	1 18	.694	93.5	93.5	2 09 30	2 14 40	2 12 05.0
27th	9 35 A. M.	.701	90.0	90.0	2 11 35	2 13 25	2 12 30.0
	0 25 P. M.	.635	93.7	94.0	2 07 30	2 11 15	2 09 22.5
	1 20	.560	91.1	93.1	2 10 10	2 13 00	2 11 35.0
28th	9 14 A. M.	.592	85.0	87.0	2 09 25	2 13 20	2 11 22.5
	0 30 P. M.	.518	97.0	97.5	2 07 10	2 08 20	2 07 15.0
	1 05	.530	99.0	99.0	2 11 40	2 16 10	2 13 55.0

INCLINATION AND DECLINATION

Date.	Hour.	Barometer.	Attached Thermometer.	Detached Thermometer.	North End of Needle.	South End of Needle.	Mean.
1829.	H. M.	Inches.	°	°			° ' "
May 29th	9 05 P. M.	29 622	85.5	86.8	2° 09' 40"	2° 11' 35"	2 10 37.5
	0 10	588	90.5	91.5	2 06 20	2 08 55	2 07 37.5
30th	9 45 A. M.	622	87.3	88.0	2 08 35	2 10 55	2 09 45.0
	0 25 P. M.	612	91.0	93.0	2 01 15	2 10 05	2 07 10.0
	1 15	516	93.5	91.0	2 11 15	2 11 15	2 13 15.0
31st	9 21 A. M.	650	85.0	85.5	2 07 55	2 11 50	2 09 52.5
	0 17 P. M.	636	85.5	90.0	2 07 30	2 12 10	2 09 50.0
June 1st	9 25 A. M.	636	90.0	90.0	2 06 50	2 13 00	2 09 55.0
	0 35 P. M.	610	91.3	91.8	2 02 20	2 06 50	2 01 35.0
	4 20	530	94.0	91.5	2 01 40	2 10 45	2 07 12.5
2d	9 15 A. M.	540	88.5	89.5	2 08 50	2 12 15	2 10 32.5
	0 17 P. M.	530	94.5	95.5	2 06 25	2 08 10	2 07 32.5
	4 20	462	100.0	101.0	2 08 25	2 13 30	2 10 57.5
3d	9 50 A. M.	508	86.0	87.0	2 08 00	2 12 10	2 10 20.0
	0 20 P. M.	501	91.5	92.5	2 05 00	2 10 00	2 07 30.0
	4 18	420	92.5	92.5	2 01 25	2 09 35	2 07 00.0
4th	9 30 A. M.	490	92.0	93.0	2 08 00	2 11 15	2 09 37.5
	0 20 P. M.	470	95.5	95.5	2 05 35	2 10 10	2 07 52.5
5th	9 45 A. M.	488	93.0	91.0	2 01 30	2 12 15	2 09 07.5
	4 20 P. M.	411	100.0	100.5	2 12 10	2 18 10	2 15 10.0
6th	0 17	530	96.0	97.0	2 05 30	2 12 30	2 09 00.0
7th	9 10 A. M.	670	87.0	88.0	2 11 35	2 16 20	2 13 57.5
	0 14 P. M.	676	92.5	93.5	2 08 35	2 13 15	2 10 55.0
8th	9 35 A. M.	730	91.0	92.0	2 12 25	2 11 45	2 13 35.0
	0 25 P. M.	728	96.0	97.0	2 05 20	2 08 50	2 07 05.0
9th	9 25 A. M.	792	90.5	91.0	2 08 05	2 11 00	2 11 02.5
	0 15 P. M.	778	95.0	96.0	2 03 40	2 08 05	2 05 52.5
	4 20	708	100.0	101.5	2 01 05	2 08 40	2 06 22.5

Needle, East of the true Meridian, 2° 09' 46" Mean.

Add correction for Zero of Compass Box, 14 24

True Declination, Easterly, 2 24 10

II.

ON A SPECIES OF

A Q U I L A. C I R C Æ E T U S.

AND

D I C R U R U S.

By MR. HODGSON.

I.

ORDER Raptores. Family Falconidæ, Stirps Aquilina. Genus Aquila.
Species new?

This noble bird, though not, by any means, the first, is yet *among* the first, of the Eagle Race, being fully two feet eight inches long, and six and a half feet wide, with weight, strength, and vigor in proportion.

Above or along the ridge, the bill is, so far as the cere extends, nearly straight, and also slightly flattened or depressed; beyond the cere, it is (still above) sloped into the hook, and also acutely rounded. The bill is rather longer than the head, with a wide gape cleft beyond the centre of the eye.

At the gape it has great breadth which rapidly diminishes towards the hook ; but still the lateral compression is no where more than slight, so that the sides of the bill have throughout a considerable convexity. The inner margins of the bill are entire. The lower mandible is rounded beneath, and slightly and obliquely truncated at its tip.

The cere is large. The fore angle of the eye is the focus of a set of hairs which thence diverge, chiefly forwards, covering the cere as far as the nostrils exclusively. The rest of the cere is naked.

There are a few hairs under the lower mandible : none at the gape. The nostrils are placed very forward in the cere. They are cleft transversely and near to the perpendicular : in shape, like the outer margin of the human ear, which form I suppose to be that styled *lunation* by Zoologists.

The eyes have a strong brow, from under the shade of which they glance terrifically.

The tarsi are short very strong, and feathered to the toes. The toes are of moderate length, unequal, stout, reticulated, with two or three large scales at the roots of the talons. The talons are exceedingly strong, large, much hooked, moderately acute, flat within, and unequal, the hind one, and internal fore one being much larger than the central fore one, and still more so than the external fore one.

The wings are long, reaching within three inches of the end of a tail that is upwards of a foot long. The great quills are strongly emarginated within—fourth quill longest. The tail is moderate, even, consisting of twelve nearly equal feathers. The feathers of the head and neck are

narrow and pointed ; and many other of the body feathers tend to a pointed form.

The colour is, *superficially*, of an uniform very pale brown with the great feathers—such as the largest scapulars, the quills, and tail feathers—uniform dark purpurulent brown. Upon a closer view, however, it is found that the great feathers above noted, are paled nearly to white at their extremities, especially the upper extremities, and chiefly on their internal surface—that in some of the secondary quills the brown and white are mixed in the marble-fashion—and that in some again the dark color appears in the shape of regular cross bars, particularly on the inner webs of the feathers.

The down at the roots of the feathers is every where white ; and the shafts of the feathers are white near their roots ; elsewhere colored like the webs.

The greater internal wing coverts are pure white, and the tail coverts (especially the internal ones) nearly so.

The toes are yellow—the talons black—the cere and gape yellow, with a slight greenish admixture—the bill blue-black, with its basal parts paler and blue—irides, brown.

This species of Eagle inhabits that part of these mountains which is equally removed from the vast Himálaya on one hand, and the small hills, confining the plains of India, on the other. It is often seen in the great valley of Nepál, and the sole specimen I have been able to procure, was obtained there. Its manners are unknown to me.

I have no doubt that the bird above described belongs to the genus *Aquila* of Vigors (Apud SHAW's Zoology, XIII. 2, 15.) and I suppose that the slight depression of the ridge of the upper mandible of its bill towards the base is what that writer means by the "beak somewhat angular above" of his generic character. But "*nostrils rounded*" of the same character much less accurately describes the nostrils of our bird, than the equally short and technical term "*lunated*"—to which, however, I have preferred the comparison to the external rim or outline of the human ear.

Whilst I notice this deviation from the generic character as laid down by the work I have followed, I may add, that I conceive it to be unimportant, and that the bird unquestionably belongs to the genus *Aquila*. The species is probably new; since it is not to be found among the nine described in the vast and recent work already frequently alluded to. The dimensions and weight of our bird are as follow :

	<i>Fect.</i>	<i>Inches.</i>
Tip of bill to tip of tail,	2	8
Bill,	0	3 $\frac{1}{8}$
Tail,	1	0 $\frac{1}{4}$
Leg, from hip to point of central claw,	1	2
Tarsi,	0	4
Central toe and claw (in straight line),	0	3 $\frac{3}{8}$
Hind claw,	0	1 $\frac{5}{8}$
A closed wing,	1	11
Expanse of wings,	6	5 $\frac{3}{4}$
Weight,	7 lbs.	

ORDER Raptores. Family Falconidæ. Stirps Aquilina. Genus
Circæctus? Species new?

This compact, powerful, and well-proportioned bird, though considerably less than the true Eagle, just described, is yet more nearly akin in size (as in other respects) to the aquiline stirps of the Falconidæ, than to any other stirps of that family.

Having only the very slightest acquaintance with its manners, I am doubtful amid its slightly-marked characteristics, as to its proper genus. But I shall endeavour to give so accurate a description of it as to leave no room for doubt in the minds of persons more versant with Zoology than myself.

In SHAW, vol. VII. p. 157, pl. 22, a bird called *Falco Bacha* is described and figured. The bird now before us bears a marvellous resemblance to that bird in the colors of its plumage, in the shape and size of its crest, and even in its general figure and proportions. But as our bird is vastly larger than the *Bacha* and as that bird is ranged in SHAW's XIIIth vol. under the genus *Cymindis*, scarcely one of the characters of which genus suit our bird, I have no doubt it must be distinct from the *Bacha*, and not finding it any where in SHAW's great work, I venture to describe it as what is probably new. The bill is as long as the head, scarcely cleft beyond the fore angle of the eye, and of less than moderate width at the gape. Its lateral compression is considerable, so that the ridge of the bill is acutely rounded and the sides of it have hardly any

convexity. Beneath, it is obtusely rounded. Considerably beyond the cere, the bill, *above*, is straight; thence forward, regularly and gradually sloped into the curve of the hook—which latter is large and acutely pointed. The lower mandible is rounded beneath; and obtusely pointed, or, I should rather say, obliquely truncated, at its tip. The inner margins of the bill are entire. The orbits and space between the eye and the bill are naked, save a partial covering of harsh hairs, or bristles, which diverging from the fore angle of the eye, tend chiefly forwards, partially clothing the sides of the cere and curling upwards above the top of it. About the gape and lower mandible likewise are some scattered bristles. The nostrils are obliquely cleft, open, and of an irregular oval shape. The wings are long rather than moderate, and extend to less than three inches of the end of the tail, which is rather more than a foot long. They have the fourth quill longest, but the fifth almost as long; and the largest quills are slightly emarginated.

The tail is moderate, well rounded, consisting of twelve feathers. The tarsi are long, naked, reticulated, with the reticulation coarse. The toes are short, thick and fleshy, or *gummy*; the outer connected at the base to the middle one, as far as the first joint. The toes are, besides, unequal for though the lateral ones are nearly of equal *length*, the inner is *stouter* than the outer lateral, or even than the central one. The talons are stout and of fair, but not remarkable length, curvature, and acuteness. The hind talon and inner toe are the largest, and are of equal size. The central one is as long but not so stout as they are: the inner fore claw, considerably smaller and shorter. The talons are flat within. The above description tallies essentially, as it appears to me, with SHAW's generic character of the *Circæetus*, with the single exception of "nostrils pointed"—this bird's nostrils being, *rather at least*, irregularly oval.

The back part of the head is furnished with a few feathers of similar texture with the others, but somewhat elongated, and forming a sort of pendant crest. The feathers upon the body beneath are long, and have long discomposed webs. Such also are the thigh feathers. The rest of the plumes have no peculiarity. Most of them have ample webs and broad terminations. The top of the head and nape, and crest are clothed with feathers, which are black from their tips nearly to their centres, white from their centres to their roots; and as the crest, though usually pendant, is slightly erigible, when erected, a small portion of the white part of the feathers is revealed and shows like a cross bar of white on the crest. The rest of the plumes on the bird's upper surface are of a dark pur-purescent brown, which is darkest upon the lesser wing coverts, great scapulars, quills, and tail feathers. Most of the quills and tail feathers and upper tail coverts are tipped with white; and the little wing coverts are doubly dotted with white near their tips. Upon the wings and tail is one broad distinct transverse bar, running entirely through them. Above this bar, there is another, parallel to it, on the great quills; and something like this second bar may be also brokenly traced along the secondary quills, as well as on the tail feathers. These bars shew whitey-brown upon the superior surface of the quills—pure white on their interior surface. Upon the tail feathers, the lower and decided bar shews equally and fully white on *both* surfaces—but the upper and less distinct bar of the tail appears whitey-brown above, as is the case with the bars on the wings. Passing now down the inferior surface of the bird's body we note, first of all, that the eye-lashes, and bristles covering the sides of the cere, are black: the throat, black-brown: the neck, same as above, but paler: the breast, belly, thighs, and tail-coverts, pale dirty brown-ish-yellow with either ocellations or bars, of pure white, edged with clear brown, disposed cross-wise down either side of each feather: the lesser wing-coverts. the same, but with a paler ground colour: the greater

coverts, regularly and equally crossed with white and black-brown throughout: irides, *orange* yellow: cere and orbits, and naked space between the eye and the bill, full *clear* yellow; bill, leaden-blue, with a black hook: legs, obscure dirty yellow: habitat, same as the preceding.

This species is said by the Nipalese to feed on fish. I myself have seen it frequently perched on rocks and trees, overlooking streams that were full of fish. But I never saw it attempt to catch them. I have seen it seize pigeons, and one of my specimens had a small innocuous kind of snake taken out of his throat after he was killed. It ordinarily soars very high: and the male and female are almost constantly together. The female differs from the male chiefly, in having a smaller crest and less full-bodied colours. Proportions, size, and weight as follows:

	<i>Feet.</i>	<i>Inches.</i>
Tip of bill to ditto of tail,	2	5 $\frac{1}{4}$
Bill,	0	1 $\frac{7}{8}$
Tail,	1	0
A closed wing,	1	6 $\frac{1}{2}$
Total leg (as before,) ...	0	11
Tarsus,	0	4 $\frac{1}{4}$
Central toe and talon,	0	2 $\frac{3}{4}$
Weight 4 & $\frac{3}{4}$ lbs.		

III.

ORDER INCESSORES. Tribe Dentirostres. Family Laniidæ. Genus
Dicrurus.

*

Dicrurus cœrulescens ?	} SHAW, 13. 137. 8. 9. Do. 7. 291. &c.
Di. æratus ?	
Di. Indicus !	

Bill rather longer than the head, very smooth, stout, nearly straight, at the gape broader considerably than high, base clothed with short quasi-setaceous feathers and stout bristles, pointing forward and outwards : both mandibles with their sides rounded and tips acute ; *upper* mandible somewhat sharpened above or along the ridge ; its edges somewhat overlaying those of the lower one ; slightly dentated and hooked at the tip : *lower* mandible, rather flattened beneath, slightly emarginate and recurved at the tip. *Gape* rather wide, and furnished with bristles. *Nostrils* round, lateral, basal, partially concealed by short quasi-setaceous feathers. *Legs* rather short : four toes, three before, one behind ; central toe and claw equal to tarsi ; outer fore toe not quite so far cleft as inner ; hind toe and claw stouter than central fore ones : *claws* very sharp and hooked.

Wings long and acuminate. Fourth quill longest ; first very insignificant. *Tongue* flat, of moderate length, near the tip cartilaginous and jagged, tip forked. *Tail* very long and conspicuously forked ; consisting of ten feathers disposed in pairs, whereof the uppermost pair are shortest, and lowest longest by one and a half inch ; intermediate ones regularly graduated in length.

The *full-grown male* bird measures from tip of bill to tip of tail upwards of twelve inches, whereof the tail to its roots, is seven. The expanse of the wings is seventeen inches : when closed, and measured from shoulder-tip to point of longest quill, the length is nine inches. Bill to gape, is more than an inch long. The weight of the grown male is 1 oz. 7 or 8 dr. The head and bill are somewhat large, but not disproportionately so ; and these parts, as well as the tongue and legs, have an extremely corvine character. Except an oval spot of pure white on each side the gape, the plumage is entirely black, richly glossed with deep blue, which sometimes shews green, especially on the wings and tail. The inner webs above, and whole inferior surfaces of the wings and tail are unglossed—every where else the gloss prevails. The bill and legs are pure black : the irides red brown.

The female is nearly as large as the male. She differs from him in not being so deeply coloured and glossed above ; and, in having the upper and under tail coverts, the internal wing coverts, the sides of the body, the breast, abdomen, and vent, spotted and shaded with white.

The spots are very distinct on the inner wing coverts ; and the tail-coverts have their tips distinctly white ; but upon the body beneath the white is blended with the black, so as to form an iron-grey colour. The thighs of the female are immaculate black, like those of the male.

The young birds for some time resemble the female in plumage and even after they are fully grown, the young males long continue to shew more or less of white on their plumes, especially on the tail coverts. A spot of white is often seen on their breasts, and often on the tips of the tail feathers.

From a careful examination of several of these birds—males and females—young and old, I am led to suspect that the three species in SHAW, referred to above, are only more or less accurate descriptions of one and the same species. The Laniidæ of this work exhibit—according to STEPHENS' new arrangement—a world of genera separated, I humbly think, with more cunning than wisdom. But be that as it may, I trust that the accurate details now furnished from ample observations, will enable the future Ornithologist at least to give an accurate and full account of the Indian *Bhúchàng*, and to determine whether SHAW's three species be really distinct or not.

The bird is found very generally throughout the vast Bengal presidency, and also in the mountains confining it on the east and north. It is very common in the valley of Nipal; is familiar with man; and seems to love the neighbourhood of country houses.

It is monogamous, and associates usually in pairs—but five or six are always found in the same vicinity. It is capable of a very rapid forward flight, and when exerting its speed makes a loud whirring noise with its wings. Commonly it makes short jerking parabolic flights from and to a bare tree, whereon it sits watching for insects and thence darts, as above described, to catch them on the wing. I have been told it will sometimes seize very small or young sickly birds—but never saw it do so: and its food undoubtedly consists, in the main, of insects, and chiefly of winged ones. It likewise feeds upon the vermin that harbour in the skins of sheep and oxen; and is constantly seen attendant upon herds and flocks, perched upon an animal's back, and searching the skin with its bill.

It is very bold, frequently pursuing Crows and Kites, that come near its perch—and such is the rapidity of its flight that it can overtake the

Kite when he uses his best efforts to outfly it. When up with him it darts at his head continually from above—but never—so far as I have seen, actually strikes him. All birds seem afraid of it, and it of none. It is very vivacious, darting about all day, and all night too, when the moon shines. It seems to love dawn, twilight, and moonlight ; and at such times especially continually utters (one bird responsively to another) its agreeable whistling note of two prolonged syllables, which the Hindoostanies fancy they can frame into *Bhúchàng* ; the Bengalees, into *Phingah*—and by those names accordingly, the bird is known to them respectively. Strange but true, its note is more pleasing than that of the vulgar Indian *Bulbul* !

It nidificates early in June, in the branches of trees, making its nest neatly of small grass roots, and laying usually two or three eggs, which are white, spotted with deep crimson, especially at the broad end. Both sexes tend the young, and most assiduously feed and defend them.

There is another Shrike found in the Nepalese Teráí and mountains, and also in the great valley of Nipal, which bears a strong general—but not particular—resemblance to the one above described—but having already stated that the diagnostics of the modern genera of the Laniidæ, are to my eyes very indistinct, I shall not attempt to assign its genus—but briefly describe it by comparison with the foregone.

It differs in having the upper mandible of the bill laterally compressed, and also much more strongly dentated and hooked—in having the tail even at the end and the uppermost pair of feathers longest, the lowest pair, shortest ; and in having twelve, instead of ten feathers, in the tail—and lastly, in having the shoulders of the wings united in a nearly straight line to the body from the second joint instead of descending in an acute angle towards the first joint.

To these differences I should add that the tarsi are rather longer and smoother than in the foregone.

The plumage too is ~~totally~~ different, and is as follows. The top of the head, dorsal neck, upper part of the back, and scapulars (besides having looser and more elongated webs than in the foregone) are slaty blue. A broad line of perfect black passes round the base of the upper mandible through the eyes to the sides of the neck. The throat, cheeks below the eyes, and centre of the breast and belly, thighs, internal wing coverts, and inner margins of the quills, on their internal surface, white.

The sides of breast and belly, and the lower part of the back, the upper and under tail coverts, and outer margins of the lateral tail feathers near the body, are pale clear ferruginous—the wings and tail dusky, the former with the outer margins of all the feathers, but the great quills longitudinally striped with rufescent white, and the latter with all its feathers tipped with the same colour.

This bird is also somewhat smaller than the other, measuring only in extreme length nine and half inches, whereof the tail, to the roots, is five inches. The tail therefore is as long in proportion as in the foregone; and it must be obvious from the above description of it that, when slightly expanded, it is wedge-shaped. The irides are dull brown: the legs and bill are black, as in the foregone; and I need hardly add—having already asserted the general resemblance of the birds—that the bill, tongue, nostrils, legs, wings, and tail, are alike in form and proportions, saving the difference specifically noted.

This bird is much rarer and shyer than the other, and I have had no sufficient opportunities of observing its manners.

The female of this species is rather less than the male. Her colours are all duller. She wants the black zone round the base of the upper mandible of the bill. Her breast and sides of her body are crossed with small crescents of a faint dusky hue: and the *base* of her bill is paled, nearly to fleshy white. In all other points she resembles her mate.

Valley of Nepál, June, 1829.

III.

SKETCH

OF THE

GEOLOGY OF CENTRAL INDIA,

EXCLUSIVE OF MALWA.

By JAMES HARDIE, Esq.

READ THE 8th OF APRIL, 1829.

IN the following Communications I have endeavoured to convey a general idea of the Geology of Central India, in the hope that, as opportunities occur, I shall be enabled to fill up the slight sketch now offered, by minuter descriptions of individual portions of this extensive tract of country.

Nomenclature adopted in this paper.—Before describing the rocks of this district, it will be as well, to prevent confusion, that I should explain the nomenclature which I have adopted.---A looseness in this respect has been an endless source of confusion in the science of Geology, many different names being applied to the same rock by different observers, and it is greatly to be wished that some specific plan should be had recourse to. As the case now stands, I shall simply endeavour to make myself understood.

I propose including all the rocks which occur in this district under the following heads, viz :

Granitic rocks,	Micaceous schist,	Argillaceous,
Gneiss,	Chlorite ditto,	Hornblende rocks,
Quartz rocks,	Talcose ditto,	Greenstone,

Serpentine, Marble, and Porphyry.

Under the head granitic rocks shall be included those only which have not a slaty structure, and which are composed of *two* or more of the following ingredients ; viz. quartz, mica, felspar, cleavandite, hornblende, and occasionally steatite, talc, and chlorite. The only exception to 'his rule will be found in some varieties of rocks, in which hornblende preponderates, and which shall be placed under the head " hornblende rocks."

Stratified, as well as *unstratified*, rocks, shall be included with the granites, as every one who has visited this district must allow that distinct and well-marked granite does occur in strata ; and I am compelled to state this in opposition to the high authorities of MACCULLOCH and PHILLIPS. MR. PHILLIPS allows (see Outlines of Geology, p. 164,) that granite is sometimes found disposed " in beds which possess *the ordinary characters of stratification*," and DR. MACCULLOCH, in support of his opinion, (see Journal of Sciences and Arts) is obliged to account for the adduced instances of stratification in this rock, by declaring that " they may all be referred to laminar concretionary structure on the large scale,"—or that the instances alluded to are " portions of gneiss of which the structure so often becomes *perfectly granitic*," or lastly, that they are " veins of granite traversing the gneiss in directions parallel to

the strata." I trust I shall be excused if, in describing gneiss which perfectly resembles granite, I shall include it with the granitic rocks. Their constituents are exactly the same, and the distinction does not appear to me very clear or obvious. In as far as this district is concerned, the Wernerian School, at the head of which deservedly stands JAMESON, is certainly in the right, and the name and authority of this distinguished Geologist will excuse what might otherwise have been deemed presumption in me, in thus stating my opinion in opposition to the authorities before alluded to.

There are a number of rocks in this district composed of two ingredients, generally quartz and felspar. These most frequently are found stratified—to class them with the porphyries, therefore, might lead to confusion, and this latter term shall be applied to those only which are *not stratified*, and which have a distinct porphyritic structure. Indeed this rock, so understood, is of very rare occurrence in this portion of India.—Besides, the rocks under consideration do not resemble the porphyries, on the contrary, they agree in every respect with the granites; and all things considered, I think it advisable to class them with the granitic rocks—such a classification is in exact accordance with Dr. MACCULLOCH's definition of granite, which definition I have adopted; and I have only added to his list of constituents "*cleavlandite*," which, according to PHILLIPS, is of universal occurrence in rocks of this class. I cannot say that I am possessed of any correct method of distinguishing cleavlandite from felspar. Indeed the only method I know is that of analysis—an analysis which, with my limited apparatus, I find it difficult to conduct—I have frequently, however, observed what I have been in the habit of considering as two distinct varieties of felspar in different granitic rocks, and I have no doubt but that one of these is the cleavlandite.

In describing the various individuals of this class, different adjuncts, illustrative of their composition, shall be used, and in this view of the case, the granitic rocks may be divided into the following varieties :

First.—Granites composed of three ingredients.

- A.—Common Granite—composed of quartz, felspar, and mica.
- B.—Sienitic Granite—composed of quartz, felspar, and hornblende.
- C.—Talcose Granite—composed of quartz, felspar, and talc or steatite.
- D.—Chloritic Granite—in which chlorite replaces the mica.

Second.—Composed of *four* or more ingredients.

A.—Micaceous Sienitic Granite—Sienitic granite, with the addition of mica.

B.—Talc Sienitic Granite—the same as the above, the mica being replaced by talc or steatite, &c. &c. &c.

Third.—Granites composed of *two* ingredients.

Under this head shall be included rocks, which might perhaps be classed with the compact and granular felspars. The term *white stone*, applied to the latter by WERNER, is not well adapted for this rock, as it frequently occurs in this district.—Names derived from color, are always objectionable, and, as this rock is here found more frequently of a redish color than of any other, I prefer giving it the name of granite, more especially as some other ingredient is almost universally associated with the felspar, whether compact or granular, and these pass into, and are intimately connected with, the granites—when they occur pure, the circumstance shall be mentioned. I do not feel myself called upon, or at all

qualified to give a particular name to this class of rocks, and in describing them, I shall merely state their composition; as for instance, “a granitic rock composed principally of reddish colored felspar, with minute scales of mica interspersed through its substance”—stating the relative proportions of the ingredients to each other, &c. &c. Several rocks composed of felspar and quartz, and which were alluded to above, shall also be placed under this head, and these are either large or small grained, &c. The term granitic porphyry might, perhaps, be applied to the latter.

GNEISS.—Gneiss, as it commonly occurs, requires no definition, and the only other varieties which I have observed in this district are—*First*. A gneiss in which the mica is replaced by hornblende, and to which I have applied the name of *sienitic gniess*:—and *Second*. A gniess in which the mica appears to be replaced by chlorite. To this last, the term *chloritic gniess* may be applied.

QUARTZ ROCK.—I have, perhaps, placed a greater variety of rocks under this head than I ought to have done. The immense beds of quartz rock, however, which present themselves in this district, form a very striking feature in its Geology. From the pure white semi-transparent quartz, to the more slaty varieties, where it passes into micaceous and argillaceous schists, there is a regular gradation observed, and I cannot help thinking that one general name ought to be applied to the whole series. It occurs either stratified or unstratified. The former, perhaps, where it passes into the argillaceous schists, ought to be named flinty slate. I prefer, however, retaining the name of quartz rock, as the other might lead us to confound it with a more recent formation, in which the flinty structure, as commonly understood, is a characteristic feature. When any individual of this class passes into any particular rock, the circumstance shall be mentioned, while the more compact varieties of argillaceous

schist shall be named siliceo-argillaceous schists. The term primitive sandstone, adopted by DR. MACCULLOCH, I have not made use of, from a similar objection to that stated above regarding the name, flinty slate. I shall simply describe the different varieties of quartz rock as they occur, stating their color, structure, &c.—and under this head, I shall include all those apparently simple rocks, which are principally composed of silica. Small proportions of other ingredients may be associated with this, but the name quartz shall be retained as long as they preserve an *apparently homogenous structure*.—Quartz rock, as I have before stated, of almost every variety of structure, occurs in this district, associated with all kinds of rocks, such as micaceous and argillaceous schist, granite, &c. In all these it occurs pure, and is also seen passing into them, and acquiring different shades of color from intermixture. This circumstance alone presents a great objection to the division of the rocks of this district into submedial and inferior orders.

Hornstone, is a name applied by Captain DANGERFIELD* to many of the quartz rocks of this district:—this name might lead us to confound them with the hornstones of the trap formation, with which they have nothing in common. Besides, he has given this name to two rocks of very distinct and different series; viz. to a rock associated with those of a decidedly old class, and to another, which overlies the sandstones and

* Since writing the above, I have heard with sincere regret, that this Scientific Officer is no more—and I cannot resist the opportunity of paying my humble tribute of admiration to his memory. We cannot be too grateful to him for the light he has thrown on the Geology of Central India, at a time, too, when Geological Science was less understood and less cultivated than at the present day; and in this expression of my individual feelings I know I shall be joined by all who take the least interest in scientific pursuits. The rough copy of this paper was drawn out before the melancholy intelligence reached me, and I have not deemed it necessary to make any alteration in it, as to substitute the *past* for the *present* tense. In a climate like this, how short the space which separates life from the grave.

sandstone slates of the north of *Malwa*. The latter is universally associated with a breccia, contains iron ore in large quantities, and sometimes assumes the appearance of a nearly pure or ferruginous quartz rock. Mr. PHILLIPS, in describing primitive sandstone, which he classes with the "inferior rocks," says (p. 158, *Outlines of Geology*,) that "detached fragments of gneiss and clay slate occur in it," the clay slates are classed with the "submedial rocks." In this case, however, the clay slates must be of more ancient formation than the primitive sandstones, on which they are found imbedded—Another strong objection to his classification.

MICACEOUS, TALCOSE and CHLORITIC SCHISTS.—These require no definition—they are found passing into, and alternating with each other, and into other rocks.

ARGILLACEOUS SCHIST.—This name, adopted by Dr. MACCULLOCH, from the French, appears to me apt and comprehensive, and by it I mean to indicate all those rocks which are usually included under the heads "clay slate" and "grey wacke slate." Many of the argillaceous schists of this district approach to the nature of grey wacke slate, as commonly described. The transition from the one to the other, however, is so gradual, that the more I have seen of these rocks, the more I have been convinced that one general name ought to be applied to the whole. The nature of each variety of argillaceous schist will, of course, be described, and different adjuncts derived from their external characters, &c., made use of; such as—micaceous, talcose, chloritic, siliceo, argillaceous, wackaceous, friable, sectile, &c., and when they approach to, or pass into, any particular rock, this also will be mentioned.

HORNBLENDE ROCKS.—This will include hornblende rock and hornblende slate. Some of the varieties of hornblende rock might be

included with the granites composed of *two* ingredients, such an arrangement, however, would separate them from the pure hornblende rock as well as from the hornblende slates, with both of which they are intimately connected, and would only lead to confusion. All rocks, therefore, in which hornblende preponderates, shall be placed under this head.

GREENSTONES.—Including greenstones and greenstone slates, or schists. Under this head will be placed only those rocks which *resemble the greenstones of the overlying trap formation*, and which have a more homogeneous and earthy aspect than the hornblende rocks. The more distinct varieties of greenstone slate only shall be included in this class—the more indistinct with the argillaceous schists—the phrase approaching to greenstone slate being prefixed.

SERPENTINE.—This requires no definition. Mr. PHILLIPS states, that serpentine, which he classes with the submedial rocks, occurs also associated with gneiss and mica slate.

MARBLE.—This will include primitive limestone and primitive dolomite—with these mica, and occasionally other ingredients, may be associated.

PORPHYRY.—I have before stated that this name shall be applied only to the well-marked varieties of this rock which occur *unstratified*. Indeed the porphyries of this district, may generally be classed with the granites, &c., in which case the term porphyritic shall be prefixed.

In the above I have only availed myself of names already in use, and I have avoided, as much as possible, having recourse to those endless distinctions, depending on minute shades of difference, which are more in the province of the Mineralogist than the Geologist. If I can

succeed in making myself understood, it is all I hope for. In describing the newer classes of rocks, I shall endeavour to follow the arrangement of CONYBEARE and PHILLIPS, an arrangement distinguished at once by its simplicity and accuracy; but, till the second part of their *Geology of England* appears, to which every Geologist must look forward as the future text-book of his studies, I must content myself with giving as minute a description of the rocks of this district as I can, so that any one who undertakes the task of drawing out a general *Geology of India* shall, I trust, be able, from these descriptions, to class and arrange the different rocks alluded to, after any system which he may chuse, and that the work which has been so ably begun by Mr. CALDER, shall soon be finished.

In the above arrangement I have included only the rocks of the district in which I am placed, in as far as I have had an opportunity of examining them; but I by no means wish it to be understood from this that no other varieties of rock occur in the extensive tract under consideration.—Such an assertion, the opportunities I have had of examining it do not entitle me to make, and I shall reserve to myself the privilege of adding to the number when occasion shall require.

PROBABLE LIMITS OF THE PRIMITIVE FORMATION OF CENTRAL INDIA.
—I shall now proceed to offer a few hints relative to limits of the great primitive formation under consideration.—I am sorry that most of my remarks on this head are merely conjectural; I offer them, however, with the hope that they may prove useful to future observers, and that their correctness or incorrectness will soon be satisfactorily proved.

This tract, then, includes within its limits the northern part of *Guzerat*, the greater part of the district of *Bayur*--the districts of *Serúl*--*Mewar*--*Marwar*--*Ajmer*--and *Jaypur*--with, probably, portions

of the contiguous districts.—The great central range of hills, and by collateral, or rather concentric ranges of which the valley of *Udaypur* is surrounded, forms, as it were, the back-bone of this portion of the country. To the north it passes through the *Ajmer* district, and extends south towards the *Narbudda*, the line of continuity between it and the primitive formations of Southern Hindostan, being interrupted by the great overlying trap formation which extends from the north of *Malwa*, running across to the Coast south of *Baroda*, and which, from thence, may be traced skirting the ocean as far as Cape *Comorin*, being continued even into the Island of *Ceylon*. To our south and south-west, we have the diluvial formations of *Guzerat*, which are probably succeeded, in a northerly direction, by rocks of a decidedly new class. I have every reason to believe that a series of newer rocks occur to our west. I have seen specimens from *Kutch*, the banks of the *Run* and *Jesselmer*,* of a decidedly recent formation. Salt Lakes are known to occur in the districts both of *Jesselmer* and *Bikaner* to our N. W.; the rock salt of *Lahore* is well known, and this last mineral, we are also informed, is of abundant occurrence in the Desert. Directly to our north too, we have every reason to conclude that a similar formation exists. The *Sambhar* Lake, which lies betwixt *Ajmer* and *Jaypur*, though, as I am informed, situated in a primitive district, is salt. Indeed, all this portion of India is supplied from the lake in question with salt for common domestic purposes, and almost all the wells in the north of *Ajmer* and *Jaypur* are impregnated with muriate of soda. Now, the only conclusion which we can draw from this circumstance is, that a rock salt formation occurs somewhere to the north of these districts, and at no great distance from them.

* A compact brownish limestone from *Jesselmer*, containing numerous but indistinct traces of organic remains, has been used extensively in the Commercial Lithographic Press of Calcutta, and it has been found, for all common purposes, a good substitute for the expensive European stones.—The public are indebted to Lieutenant J. T. BOILEAU, of Engineers, for bringing this stone to notice.—SEC^y.

The formation under consideration, I have traced east, through the *Ajmer* and *Jaypur* districts, as far as *Biana*, where it is succeeded by the sandstones of the *Bharatpur* and *Agra* territories, opportunities having occurred to me of making observations on this large tract, both on the direct route from *Nasirabad* to *Biana*, and on the route from *Udaypur* to the same place, via *Tonk*, the capital of *Amír Khan*.—The *Bharatpur* and *Agra* sandstones may, very probably, be connected with the formations which we have every reason to conclude occur to our north.

The southern portion of this formation is bounded to the east, by the great overlying trap formation of *Malwa*, which terminates a short distance to the north of *Nimach*; and interposed between this overlying trap formation and the primitive strata, is a narrow belt of secondary rocks, which skirts the trap as far as it has yet been described.

For the distance of about thirty-six miles north of the termination of the said trap, we have also secondary rocks, which are succeeded by primitive strata.

The boundaries of this primitive formation in the directions of *Harouí*, *Ságar* and *Bundelkhand*, I have not by me the means of ascertaining.*

With regard to the narrow belt of newer rocks above alluded to, I have little to add to the excellent account given of it by Captain

* I have only a confused recollection of Mr. CALDER's paper on the Geology of India, derived from the Newspaper account, and the same remark may be made regarding the excellent papers of Captain FRANKLIN, &c. read before the Society. Had I had these by me, I should have doubtless been enabled to fill up many of the blanks in this slight sketch. As it is, I am obliged to trust to my own knowledge, however limited, rather than run the risk of committing mistakes by making use of such imperfect recollections.

DANGERFIELD in MALCOLM'S Central India. I have had but few opportunities of examining it; besides, to enter into particulars would be out of place in my present communication, and I may, perhaps, hereafter recur to the subject. I cannot refrain, however, from giving the following few particulars, as they may serve as hints to any one who may hereafter examine this formation.

Proceeding from *Udaypur* to *Nímach* directly east, we have a succession of primitive rocks till we reach *Nakúm*, a village about thirty-six miles west of the last-mentioned cantonment. At *Nakúm*, and for a short distance to its east, we have still primitive rocks, but embedded in these we observe the first indications of an approaching newer formation. The hills at *Nakúm*, which are craggy and precipitous, are composed of quartz rock of a white color, traversed by numerous seams and cracks, but which is nearly pure, and is arranged in strata conformable to the other primitive rocks of this district. In this quartz are small belts of a ferruginous variety of the same rock, of a dark yellow color, and approaching to the nature of jasper; and embedded in it, also in small quantity, is a quartzose conglomerate, which is the first indication we meet with in travelling east of a rock of this nature.—Alternating with the above, and in strata similarly arranged, is a rock composed of white quartz and red felspar, exhibiting a porphyritic structure, the basis being of felspar—some of the specimens present a partially conglomerate appearance. The general structure of the rock, however, is granular porphyritic; and in conformity with the arrangement which I have adopted, I must class it with the granitic rocks as a granitic porphyry.

Proceeding to the east of this formation, we have the surface generally covered with soil and vegetation, and numerous low rounded and conical hills are seen rising around us. The country, too, has a

waved appearance different from the perfectly level plains of *Mewar*, and the hills rise less abruptly. On reaching *Bári*, thirteen miles west of *Nímach*, these hills increase in number, and a low range traverses the line of march. We have now got among rocks of a newer formation, which form a portion of the narrow belt above alluded to."

The lowest series of this belt consist of sandstones, sandstone slates, and a schist, which on one hand passes into sandstone slate, and on the other somewhat resembles the shales of the coal formation, and which passes into an argillaceous marl slate—the sandstones are, generally speaking, quartzose, fine grained, with an argillaceous, or ferrugino-argillaceous cement. The characteristic color of these sandstones is variegated—some are of a reddish color with white spots, and others are white or grey with reddish spots, while others again exhibit a zoned aspect. This rock is either compact, or passes through every variety of structure till it becomes nearly soft and friable. It is sometimes too, though rarely so, large grained, approaching to conglomerate.

The sandstone slates differ little from the above in point of color, but they have a distinct slaty structure, the slabs varying in thickness from two inches to quarter of an inch, and some of them may be even split into lamina as thin as common paste-board. Both of the above rocks, but more particularly the sandstone slates, are traversed in very many instances by numerous seams, running at right angles to the strata, and dividing the mass into a number of square and rectangular portions. Mica is of very abundant occurrence on the sandstone slates, it is always of a grey color.

The shales and argillaceous marl slates, into which the last passes, are also of a variegated color. At *Bári*, they are of a greenish grey color,

sectile, with rather a greasy feel, fine grained, and containing minute scales of mica. They acquire a reddish ferruginous crust on exposure to the air. In other situations they are fawn-colored—in others whitish, or light buff, with streaks of a purplish color,—in others they approach to the nature of pipe-clay, with a distinct slaty structure—while in others they resemble a fine grained sandstone slate. In these we also observe the seams, above described, which run at right angles to the strata.

The above series of rocks occur in strata, generally slightly inclined to the S. E. and E. Sometimes, also, the strata are almost horizontal, while at others they exhibit appearances of a curved or saddle-shaped stratification. The hills are all low, and are topped by a rock hereafter to be described. Organic remains appear to be of very rare occurrence in this formation, and I have only met with one specimen from the neighbourhood of *Barí*. It occurred in a soft shale, somewhat resembling the shales of the coal measures. The specimen in question appeared to me, to be the impression of a portion of a cryptogamous plant. This plant appeared originally to have been expanded in a fan-like form, with ribs of about quarter of an inch in breadth, radiating from a common centre, the interior or central part of these being occupied by three or four longitudinal tubes. The diameter of this plant, or fan-like portion of a plant, might have been about five and half inches. The impression appears to have been covered with a thin bituminous crust, portions of which still remain. Except this, I have met with no other appearance of organic remains. Captain DANGERFIELD mentions the occurrence of impressions of ferns, in a fine-grained sandstone slate, at *Jíran*, and it is probable that the rock in which these occur is similar to the one just described.

With regard to the age of the above formation, I am inclined to believe with Captain DANGERFIELD, that it ought to be classed with the

new red sandstones, (the red marl or ground of the English Geologists.) To the character of variegated, the sandstones, &c. are undoubtedly entitled, and the red ferruginous appearance of the soil, which is universally observed, is also characteristic of the above formation. Indeed the whole appearance of the rocks composing this series, is in exact accordance with that of the new red sandstones as described in Europe. The great characteristic of this formation is, however, as far as I know, wanting—I allude to the rock salt and gypsum, which are almost universally found associated with it. These certainly occur to our north, but a large primitive district intervenes, and the only indication which I have seen of salt is an efflorescence which occasionally appears at the surface, containing a large proportion of muriate of soda.* All things considered, however, I perfectly agree with Captain D. in classing these rocks with the new red sandstones, and I shall not be at all surprised, if future observations should discover them to be a continuation of the saliferous sandstone formation described by Captain FRANKLIN, and that they may be traced through the *Bharatpur* district, north towards *Dehli*, and may thus be connected with the rocks containing salt and gypsum, which must occur to the north of *Ajmer*, and be continued into *Lahore*, *Multan*, &c. south towards *Kutch*, extending, perhaps, even into *Persia*, and forming a zone around the great and elevated primitive formation of Central India, and separating it from the primitive formations of the *Himalaya* mountains. Traces of a formation, similar to the one above described, I have also noticed on the route from *Baroda* to *Udaypur*.

The very partial occurrence of organic remains on the above series of rocks, ought not to militate against the position I am endeavouring to

* See also Note to page 53.

establish. These are very rare, and besides it is not impossible that the shales in which these occur, may belong to an older class similar in position to the rocks of the north of Germany, (see CONYBEARE and PHILLIPS, page 311,) which overlie the coal measures. I have never seen any traces of them in the well-marked sandstones or sandstone slates.

Excepting in iron, the above series does not appear rich in metalliferous substances, neither have I met with any variety of simple minerals in it. I have occasionally seen, however, specimens of a fibrous variety of quartz disposed in small veins, or rather laminae, interposed between the strata; and Captain D. mentions the occurrence of a "fat yellow clay," embedded in the sandstones.

The next rock which claims our attention in the above series, is the limestone on which this belt abounds, especially towards the north. I have little to add to the description of its external appearance, mode of occurrence, &c. as given by Captain DANGERFIELD; and, if I shall have occasion to differ from him respecting the age of this rock, I shall do so with all humility, fully aware as I am of the difficulties attending this branch of my subject. It is not improbable that two distinct varieties of limestone may occur in this belt, the one belonging to the mountain limestone formation, in which class Captain D. seems inclined to place all the calcareous rocks of the portion of the district under consideration; but the one which I am about to describe *overlies* the sandstones and sandstone slates, and I feel disposed to believe that it belongs to the lias formation. Perhaps, too, in addition to the above, there may be a formation of magnesian limestone of the English Geologists in the magnesia limestones described by Captain D. On this point, however, I can give no information, as I have only met with one variety characterised in every position, where I have had an opportunity of examining

it, by a *similarity*, or rather *identity*, of *organic remains*. As I said before, however, the opportunities which I have enjoyed of making observations on this belt, have been very limited.

These limestones, then, occur distinctly stratified. They are of a close texture, and of a dull color, generally greenish blue or lead grey—sometimes, too, they have a reddish tinge,—in other instances they are dirty white, while in one situation I have seen them of a brownish black color, and these latter emit a disagreeable smell on being rubbed. They *never occur variegated*, nor do they admit of a high polish, or of any depth of tint. On exposure, the surface acquires a duller aspect, and becomes slightly argillaceous. They are, generally speaking, compact, and many of them may be split into slabs of immense magnitude, varying in thickness from a few inches to a foot or a foot and a half. They form an excellent building stone, and are characterised by their *large conchoidal fracture* which passes, in many instances, into conchoidal splintery. These limestones sometime, though rarely so, are found larger grained. They occur in strata, generally slightly inclined in an easterly or south-easterly direction. Exceptions to this rule may here and there be observed; but it is my object in this merely to give a general description of their mode of occurrence, without descending to minute particulars. The strata are very frequently separated from each other by thin layers of a loose calcareo-argillaceous substance, and nothing like the caverns, which usually distinguish the mountain limestone formation, can be observed in the rocks of this belt.

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The ORGANIC REMAINS of these limestones are numerous; but I am sorry that my limited information on this subject will not enable me to give as satisfactory an account of these as I could wish. Though a miserable Draftsman, I have endeavoured to represent one or two

of the varieties, if possible, to render my descriptions more intelligible.

No. 1—May be considered as characteristic of this formation, and specimens, exhibiting the appearances attempted to be represented, are every where met with. On breaking a mass of this rock, we very generally observe that the surface presents the remains of what might have been a succession of cylindrical-convex,—probably solid bodies,—one fragment exhibiting these on a sort of baso-relievo, while the other presents corresponding hollows. These bodies taper to a point, and frequently occur minutely ramified at both extremities—this, at least, I have observed in several instances. They are perfectly mineralised, are of the same color as the mass, on which they appear generally as an incrustation. In one or two instances, however, I have observed the terminations of similar bodies on the mass itself, and in such cases they had obviously been arranged in bundles or fasciculi. In other instances, these cylindrical bodies appear to send off, anastomosing branches which unite them together. The latter may probably be a distinct variety. All of the above have a perfectly stony aspect, and I could discover on them nothing like a stellular structure, or any appearance of cells or pores. The length of these cylindrical bodies varies from about a foot to an inch or two inches—their breadth is also various, but they seldom occur broader than in the instance represented.

In one or two instances I have also observed longish tapering canals in the masses of limestone, which had obviously been occupied by cylindrical bodies. These, at the time of deposition of this rock, had either been detached from the bundles above alluded to, or had previously existed in a separate state. The latter I think the most probable. Could any of the above have formed the solid axis of any of the varieties of the

lamellated polypifers? some of the detached specimens somewhat resemble the styliform axis of the genus *styliina*.

No. 2—Is also exceedingly common in these limestones, and I believe that at least two varieties of it may be traced,—probably, indeed, more. The one is a flattened, polymorphous, lobated, mass—sometimes seen covering the rock, over a square surface of a foot, or a foot and a half, and even more. No. 2 is detached, generally of the size represented, and it protrudes from the mass something in the form of a pear. It has a stalk like appendix.

The above remains occur protruding into the calcareo-argillaëous substance described as separating the strata. In the solid rock, the traces of them, if perceived at all, are very indistinct, a circumstance probably owing to the delicacy of their original structure. The rounded and lobated masses, indeed, appear to terminate abruptly on the side towards the solid strata, and their whole aspect gives rise to the belief, that during the deposition of these strata, short intervals occurred,—that the remains at their surface were left *partially exposed*, and that the inferior positions of these were lost in the solid rock, while their superior were, by this arrangement, more slowly impregnated with calcareous matter, which enabled them, on the deposition of the superjacent stratum, to retain something of their original form,—and that, in consequence of the delicacy of their structure, almost all traces of organization were destroyed. The interior of these remains presents, in many instances, a pure white crystalline mass, exactly similar to the finer varieties of primitive marble,—in other instances they have a loose, inclining to chalky, structure, and they are generally covered with a brownish crust, the centre being either pure white or dirty white, and rarely of the color of the limestone itself.

It is always exceedingly difficult to refer organic remains of this class to any particular genus. I am inclined to believe, however, that these form varieties of the alcyonium, and perhaps some of them ought to be classed with the sponges. In many of them I could trace appearances of a *cortical covering*, and in one or two instances, especially in those which occur detached, I think I could discover something like a *concentric laminar* structure. This appearance is only observed at their surface, and might have been occasioned by the original animal having had a cortical covering—*nothing like fibres* could be perceived;—the above circumstance, however, inclines me to include them in the class alcyonium.

No. 3—Is occasionally met with, but is not so common as either of the two preceding. The accompanying sketch will give a pretty correct idea of the remains of this kind, both as to their size, form, and mode of occurrence in the limestone. They occur, then, in the solid rock,—are perfectly mineralised, and are of the same color as the limestone. In specimens where this limestone has a structure inclining to granular, the remains of this kind exhibit a closer and more compact texture than the surrounding matrix. They appear to have formed the ribs of some animal, probably of aquatic origin. The vertebral extremity is flattened about seven-eighths of an inch in breadth, and the whole is slightly curved, and tapers to a point. The pointed sternal extremity does not seem to exhibit an articulating surface. It is thicker than the vertebral extremity, and a sharp spine runs from the point of about two inches in length, from which spine the bone had sloped on either side.

The only other organic remain which I have observed, is a shell; but in so imperfect a state, that I cannot decidedly say under what genus it ought to be included. It had obviously been a bivalved shell; but little

except the margin of one of the valves remains, and I can only state the following particulars ; viz. that it belonged to an apparently nearly equilateral bivalve of a roundish form, about three inches and a half in width. That this bivalve was convex, inclining to flat, and that it was longitudinally rayed, the rays being convex, broadish, and striated longitudinally. The hinge portion of this shell was wanting. It appears to have had considerable thickness and strength, and in all probability belonged to a variety of *Pecten*. The number of rays could not be correctly ascertained : their breadth was about two-eighths of an inch.

The above is all the information which I can give relative to the organic remains of these limestones, as I have, as yet, met with none other, except, indeed, the impression of what every one who saw it, believed to have been that of a small flattish fish. It was about three inches in length, and its broadest portion was about one inch and a half. Though the resemblance was certainly striking, so many characteristics were wanting, that I mention it merely in this hurried way. I was rather myself inclined to consider it as the impression of one of those polymorphous bodies before described, and which assume a great variety of shapes and forms.

The above limestones do not appear to contain any metallic veins, or, indeed, many mineral veins of any kind. I have met with veins of calcareous spar in some of them, more especially in the brownish black variety before alluded to, but even this is rare. The general structure of the rock is that of a *uniform fine grained argillaceous limestone*, the surface of which, in many instances, exhibits a *dendritical appearance*, and the quarries of this rock have, in the distance, a *zoned aspect*.

The absence of metalliferous and mineral veins, &c. and of the caverns and fissures which generally characterize the mountain limestone,

would appear to distinguish the rock in question from the rocks of that formation, and all things considered, I feel inclined to believe that it is a lias—or, at least a formation nearly allied to the lias. Its *position* leads me to draw this conclusion, and there is nothing either in its *structure, mode of occurrence, or organic remains*, to militate against such a supposition. The Pecten is a shell of the lias, though certainly not a characteristic one.

The formation I have just described *never rises into hills*, but is sometimes seen occupying gentle elevations: the surface of the country where it occurs having a waved aspect. At *Cheetore*, the strata of this rock are much disturbed, and in other situations I have seen similar appearances.

We shall now proceed to describe very briefly another rock which occurs in the belt under consideration; viz. the *quartzose breccia*, before alluded to, and to which Captain DANGERFIELD has applied the name of hornstone. This belt exhibits numerous low rounded hills, hill groups and ranges,—some of the last of considerable extent, more especially the one which forms the boundary of *Meywar* and *Harowtee*. These hills do not rise higher than three hundred feet above the level of the plain, and the majority of them average below this height. Their upper portion is formed of this quartzose breccia, which rests immediately on the sandstones, sandstone slates, &c., which rocks form the base, and very generally the central regions of these hills and hill ranges. This breccia I have never seen *in low situations*, or resting on the limestones. The shape of the hills is sometimes conical. This is particularly the case with detached hills and groups, but the ranges generally exhibit an even and uniform appearance, and the summit is occupied by a table land, or a gently waved plain. Some of the detached hills also present this

shape, an excellent example of which we have at *Chitor*, the ancient capital of this country, which is situated on an isolated hill near the boundary range before alluded to.

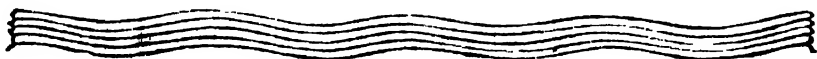
The slightly waved plain, occupying the summit of the hill on which this ancient city stands, or rather stood, for it is now in a complete state of ruin, is said to be about fourteen miles in circumference. Its length is six miles from N. to S.; its breadth varies from quarter to half a mile.

This breccia passes into a variety of quartz rock, sometimes nearly white, more generally ferruginous, and in this case it is of a reddish color; it also occurs of a bluish green color. The purer varieties are distinctly stratified, and some even approach to slaty. The strata are sometimes almost horizontal, in other situations they are waved or saddle-shaped.

The rock in question sometimes assumes a very beautiful aspect. On a hill to the north of *Nimach*, I have seen it with a base of the nature of agate-jasper, containing small rounded portions of quartz, and exhibiting minute drusy cavities, lined with quartz crystals: the whole being capable of receiving a high polish. At *Bári* it occurs both in the form of a nearly pure quartz rock, horizontally stratified, and of an unstratified breccia, composed of angular portions of pure white quartz, and a red somewhat agatose variety of the same. This rock also occurs exhibiting something of the appearance of the millstone grits.

A very characteristic feature of the hills and hill ranges of this formation, the conical hills of course excepted, is the bluff, in many instances perfectly perpendicular crag, which their summits presents. The bases of these hills, &c. are formed, as before stated, of the sandstones

and sandstone slates ; and as high as these rocks occur the slope, though abrupt, is uniform. Immediately resting on these is the breccia which presents the perpendicular crag, just alluded to, and which rises from the slope as in the sketch beneath,—the summit being occupied by a table land of considerable breadth, which gives rise to the even and uniform aspect which the summit of these hills present.



This is particularly the case throughout the whole extent of the boundary range betwixt *Méwar* and *Haráotí*, and the hill of *Chítor* affords a noble example of this kind of structure. It is surrounded on all sides by high perpendicular crags, forming a natural fortification, which, till it was taken by *AKBER*, gained it the name of impregnable,—a name which the natives of this country still fondly apply to it. The rock forming the summit of this hill and of the boundary range, is distinctly stratified, the strata being waved or saddle-shaped,—the elevated plain on which *Chítor* stands, exhibiting several smooth round swells, with corresponding hollows between, and the strata appearing to dip in a directly contrary direction on ascending from the east to what they do on ascending from the west. From the summit of this hill, we could observe a similar plain occupying a corresponding position on the boundary range. The diagram below will give some idea of the way in which the strata are arranged at *Chítor*.



The boundary range runs in a direction nearly north and south as far as *Chitor*, where it takes a turn to the east, and in marching from the last place towards *Nimach*, the route running parallel to—and at no great distance from—the base of the hills, the line of demarkation betwixt the two varieties of rock forming them could be distinctly traced, and it appeared to me that the superior strata had accommodated themselves to the form of a previously existing range, filling up all irregularities, and presenting at their summits, the even line before described. The base and lower portions of the hills are covered with vegetation, owing to the softer and less durable nature of the sandstones, &c. forming them; and the crags rising abruptly above this jungle, appear like *huge walls raised artificially*, presenting to the view the bare rock, apparently arranged in horizontal strata, but which, in fact, presents the waved aspect just described. The rocks so situated, as far as I have had opportunities of examining them, are ferruginous quartz, or a siliceo-ferruginous grit, containing occasional beds of breccia. Many varieties of the series of rocks which I have named quartzose breccia, may probably be found in this range.

The rocks of the formation thus briefly described are characterized by the large quantities of iron ore contained in them. This ore occurs in small beds, veins, and in the form of embedded nodular concretions. These latter sometimes exhibit a jaspery aspect—Botroidal red hæmatite, common hæmatite, red iron ochre, and sometimes magnetic iron ore—are met with, and the whole surface of the crag frequently assumes an iron-shot appearance. Iron also occurs in minute grains, disseminated through the mass. This rock, either in its purer or brecciated form, never occurs loose or friable. The cementing medium of the brecciated variety is generally siliceo-ferruginous, and some of the specimens greatly resemble the coarse old red sandstones. I have met with no organic remains in this formation.

I was at one time persuaded that the above rocks were of analogous formation with the *iron sand* of the English Geologists—though in their structure, and in many of their characters, they do not resemble the rocks of this formation, still these characters might have been modified by many and various causes. Their position gives some color to such a supposition, and a breccia, somewhat similar to the one described, is mentioned as associated with the iron sand. On this point, however, I prefer saying nothing more. I am anxious to give as impartial an account of the rocks as they occur, as I possibly can; and it is difficult, when once we have adopted an opinion, to void trying to trace analogies which exist more in our own imaginations than in reality—not that I believe that any individual would willingly deceive in matters of this kind, but the fact is we are deceived ourselves. It is thus that science degenerates into a system of vague hypothesis.

The plains of this portion of the country are strewn with numerous rolled masses of the above rock, and from the isolated position which it occupies, viz. only on the summits of the hills, we may conclude that it has been *much affected by those great denuding causes* which have operated with such amazing force over the whole surface of the globe. How far this formation extends into *Haráotí* I know not—Captain DANGERFIELD in his map, lays down this district as a formation of “*hornstone and porphyry*.”—But whether this hornstone be the same rock as the quartzose breccia or not, I have had no opportunity of ascertaining. As I before stated, he has applied the name to two rocks of very distinct series. Large blocks of this quartzose breccia are constantly observed at the base of the hills arranged in large globular heaps. These are detached from the crags generally during the rains. The reason of this is obvious. The water having penetrated into the rents and fissures of the rock, is exposed to the heat of a nearly vertical sun, which usually bursts out after the first fall of rain—the expansion thereby occasioned

is great, and the blocks in question are detached, while the same cause accelerates the decomposition of the softer and more friable strata—thus affording a thick soil which is rich and fertile, and in many situations covered with jungle.

Regarding the rocks of this narrow belt I have only further to add, that the *strata*, in the neighbourhood of the primitive formations, *are more inclined than in other situations*. This remark holds good in the case of all the rocks of this belt. The wells are seldom deep, water being generally obtained near the surface. This circumstance is owing to the numerous artificial lakes and tanks which have been formed in this district—and it is seldom necessary to penetrate the strata beyond the level of these lakes, and never beyond the level of the nullahs and streams. I may also mention that, in addition to the fact of springs of water issuing from the strata of the low boundary range, &c. as stated by Captain DANGERFIELD, that there is a spring at *Gangra*, twelve miles N. W. of *Chitor*, which issues from the sandstone slates near the base of the group of hills which are there observed. This spring is *sensibly hot*. When I visited it—it was during the cold season, and we had ice daily in our *shorais*. The thermometer in the morning standing below 40°, and during the hottest period of the day, never rising beyond 47°; but when plunged into this water it rose to 80°. It issues from the rock at the surface, and the fountain is looked upon as sacred by the natives. It has no sensible taste, and appears to hold little foreign matter dissolved.*

* A bottleful of this water, afterwards subjected to the following tests, gave the results as below. Nitrate of silver throws down a dark precipitate. A paper, dipped in a solution of lead, and plunged in this water, acquires a dark color; and a solution of acetate of lead, also throws down a dark precipitate. Tincture of galls has no apparent effect, neither has the addition of a large quantity of alcohol. A quantity of the water was boiled, the contact of atmospheric air being

My observations on this belt are confined to its most northern portion, and they may serve as a supplement to Captain DANGERFIELD'S account, to which I beg leave to refer for further particulars.

But it is now time that we should return to the consideration of the primitive strata, and I shall premise my remarks on this head by a general description of the external features of the country. The southern portion, then, of the tract under consideration, is mountainous, and consists of numerous groups and collateral ranges of hills, studded closely together, and separated from each other by narrow ravines and deep valleys. These hills do not rise to any great height, seldom to more than five hundred feet above the level of the plains;—they run generally in a northerly and southerly direction, and instances occur where individual hills attain the height of twelve hundred feet. In many situations, too, the country presents a mammillary aspect—an aspect frequently observed to characterise the lower granite tracts in other parts of the world. In this southern portion are included the northern parts of *Guzerat*—the district of *Bayar*—portions of *Rath*,

excluded, and to two separate portions of this, the sulphuric and nitric acids, were severally added, no precipitate or cloudiness was observed even on the addition of a large proportion of alcohol to the portion containing sulphuric acid. From this it would appear that *no hydrosulphuret of lime* is present, which is usually the case in hepatic waters. A sediment, in minute quantity, of a light color, and which effervesced with acids, remained after the boiling. This was carbonate of lime. The water boiled and freed from its gases, gave a white precipitate, on the addition of sulphate of silver. From the above it follows, that sulphurated hydrogen, carbonate of lime, and muriatic salts, were present. This water emits the peculiar odour of sulphurated hydrogen, though faintly so when it is perfectly fresh, and the ingredients present appear to exist in minute proportions, the exact proportion I had not the means of ascertaining, as the bottle containing the water was, accidentally, broken after the above experiments were concluded. The muriatic salt indicated by the test, is probably *muriate of soda*. At least a very small quantity of the water which remained in the broken bottle gave, on evaporation, a minute portion of a white substance, having the taste of common sea salt. The quantity was too small to be examined.

Shiri, and the south of *Méwar*, and it is inhabited by the numerous and predatory tribes of *Bhils*, *Mínahs*, *Grasias*, and *Kúlis*. It presents a wild and bleak appearance, and exhibits, on a small scale, all the bold and striking features of an Alpine country. It is traversed by numerous deep and rugged ravines and ghauts, on the brinks of which are frequently seen the villages and huts of the rude people by which it is inhabited. As we proceed north, the country becomes more open—the valleys more extensive, and a narrow belt, exhibiting a mammillary aspect, is very generally interposed between the large and level plains of the north of *Méwar*, of the *Ajmer* district, &c. and the more mountainous tract just described. The same mammillary belt also runs parallel to the great central range of hills so often alluded to, as far as *Kankaraoli*, thirty-six miles north of *Udayapur*, while to the east of this belt we have the usual level plains of the north of *Méwar*. The hilly tract just described may be considered as a continuation of the great central range which may be supposed to divide itself, a little to the north of *Udayapur*, into a number of collateral and concentric ranges, so that it is difficult to say which ought to be considered the parent range—and which not.

Suppose a line drawn west from the cantonment of *Nimach* to the northern extremity of the valley of *Udayapur*, it will give us a sufficiently correct boundary for general purposes, betwixt the northern and southern portions of this district *to the east of the great central range*. The northern portion is characterised by plains of large extent, which are perfectly level, and from the surface of which are seen, here and there rising *abruptly*, hills and small hill ranges and groups. In the neighbourhood of the mountainous district to the south, these hills and ranges are numerous, and they gradually decrease in number as we proceed north, till, on reaching the *Ajmer* district, we frequently find ourselves on a perfectly level plain, bounded by the horizon on all sides, and at the surface of

which the vertical strata are very generally observed. Still, however, detached groups and hills here and there present themselves. North of *Nasirabad*, these plains are bounded by the great central range, which here takes a turn to the N. E.—East of *Nasirabad*, and proceeding from that cantonment through *Jaypur* towards *Biana*, we have still the usual level plains with their detached hills and groups. These latter, in many instances, appear to form detached portions of two hill ranges, which we meet with about half-way betwixt *Nasirabad* and *Biana*, and which run parallel to, and at no great distance from each other. Frequent secondary ranges pass off from them, generally in pairs, running parallel to each other, and nearly at right angles to the parent ranges. These parallel ranges are separated from each other by perfectly level plains, with the usual detached hills, which are, in this district, generally topped by a fort or a strong-hold, and which rise *abruptly* from the surface, often exhibiting an almost perpendicular crag. South of the most southern of the two ranges above alluded to, we have also plains of large extent, the route in this direction running through the south of *Ajmer* and *Jaypur* and crossing the fertile jageer of AMIR KHAN near *Touk*. This portion is also characterised by hill groupes and detached ranges, some of considerable extent. The height of these detached groupes, hill ranges, &c. is very inconsiderable; but the plains themselves are situated high above the level of the sea, as may be seen from the measurements made by Captain DANGERFIELD; and there appears to be a gradual slope as we proceed east towards *Bharatpur*. The hills composing the central range, rise higher, and their altitude appears to become more considerable as we proceed north,—none, however, I believe, rise higher than twelve hundred feet above the level of the plains; very few, indeed, so high, and their general average may be estimated at between six and eight hundred feet.

The northern portion of this great tract is very fertile, and is abundantly supplied by water from numerous large lakes, tanks, rivers, and wells. The deep valleys of the southern portion are also fertile, but many of them are indifferently supplied with water. The splendid *Dhábar* lake, however, and several others of smaller size and less note, are situated in this portion of the country, and the great fertility of the valley of *Udayapur*, situated on the northern extremity of this southern portion, I alluded to in my last. The country surrounding *Nasírabad* forms a striking exception to the above rule.—Here the rock almost universally appears at the surface, and where any soil exists it seldom exceeds a few inches in depth.

In spite of all these natural advantages, large tracts of land are left in a perfect state of jungle, and the contrast afforded us on entering the highly cultivated provinces of the British Government, is truly striking. The above circumstance may, in a great measure, be attributed to want of confidence on the part of the Ryots, owing to the insecurity of property, which is but too often the result of Native rule. Besides, this part of India has not yet recovered from the effects of war and famine, which, not many years ago, rendered it almost uninhabited; and I believe that even now, the produce exceeds the demand.

Of the country to the west of the great central range I know little, as I have had no opportunities of examining it personally. We have every reason to believe, however, that the central range forms the highest portion of the district under consideration, with the exception, perhaps, of the immediate neighbourhood of *Abu*,—and that the country to the west of it slopes gradually towards the *Indus*, &c. How far west the primitive strata occur I know not, but that these are succeeded by secondary rocks I have before stated my belief, and I have in my possession specimens

from *Serooe*, which belong to the primitive class. I believe that the southern portion of this western tract is characterised by its broken and mountainous aspect, and that some of its hills rise to a very considerable altitude. In this part of the country is situated the mountain of *Abu*, so famous in Hindoo Mythology, which, according to Colonel TODD, rises 5,000 feet above the sea ; and from the district of *Sirohi* passes off to the west a range of hills, I believe also of primitive formation. *Sirohi* itself, especially towards the north, is described as exceedingly fertile, and capable of being highly cultivated. It is succeeded in a northerly direction by the country of *Marwar*, which is described as lying comparatively low. This last is bounded by the sterile districts of *Bikanér* and *Jesselmér*, which are situated on the confines of the sandy desert—the sands of which make yearly encroachments on the country to the west of the central range—the said range presenting an impassible barrier to their further progress east.

In concluding this branch of my subject, I may remark that those who are in the habit of travelling much in India, are constantly struck with the very different aspect which the same country presents at different seasons of the year, and hence very opposite, and even contradictory, accounts of particular districts may be given by travellers, and all of these may be correct. The increase of vegetation during the rains is a principal cause of this alteration, and it is astonishing sometimes to observe the effects of *light and shadow* in modifying the external features of the country. During the season of the hot winds, when the sky is clear and cloudless, and the sun is reflected with fearful intensity from the bare and barren rocks, nothing but ideas of desolation are excited in the mind, but after the first fall of rain the scene changes as if by enchantment—the wilder and bleaker features of the country are softened down, the desert seems at once to teem with life and vegetation—while

the clouds and mists gathering on the mountains here, exhibit them of a dark and sombre hue, and there, spots of green may be observed glittering in all the brightness of reflected sunshine. These causes not only modify the external appearance of the country, but even the *shape of the mountains seems to undergo a change.*

With regard to the ROCKS OF THIS DISTRICT, they are all probably based on granite.—Of this, however, I can offer no proof, except such as are derived from analogy, and many of the granites appear so intimately connected with the other rocks, that it is impossible *prima facie*, to say which ought to be considered the eldest and which not—a gradual passage of the granites into rocks, resembling the greenstones of the trap formation may, in many situations, be observed in this district. Dr. MUECCULLOCH has described similar appearances in Scotland, and has drawn from the circumstance conclusions, the correctness of which I cannot take upon myself either to contradict or support. — I may be permitted, however, to remark, that conclusions drawn from the external characters of rocks, appear to me liable to considerable objections. These may be modified by many circumstances. Neither can I believe that the circumstance of one rock occurring stratified and another unstratified, justifies us in concluding that these two rocks have owed their formation to different causes. In this district we often observe a rock in one situation stratified, and at a little distance from it another of an exactly similar nature, in other respects, unstratified. An instance of this kind I have particularly remarked at *Phulana*, about twelve miles north of *Merta*, where there occurs a series of alternations of a close grained grey granite, with hornblende rock approaching to primitive greenstone.—Some of the alternating beds appear distinctly stratified, while others resemble an unstratified mass, of a prismatic form, interposed among the other strata. It is impossible to distinguish which is

which, betwixt two hand specimens from the different beds, and the above difference is observed over a square surface of several yards. It would be difficult indeed to believe the two different causes had operated in forming these different beds of rock.

That granite does occur oftener in an unstratified than a stratified form I am free to confess. This is particularly the case in the well-marked varieties. It also exists in long-regular-prismatic beds—interposed among other stratified rocks, and alternating with them. These beds are certainly not subdivided into strata, but may not this have been owing to a particular arrangement of the constituent parts, and does not the circumstance of their alternating with other strata, *and the regular prismatic form of the beds, indicate a stratiform structure*, or at least something *very analogous to it*. I stated in a former paper, that I considered the granite which forms the small hills protruding through the deluvium of *Guzerat* at *Pandua*, to the north of *Balasinore*, as belonging to a very old variety, and the out-croppings of a similar formation may, very probably, be discovered in many of the granites of this district. The talcose and chloritic granites, which form the protogine of *Jurine*, the last mentioned Geologist considers very antique varieties. These occasionally make their appearance here; but, without speculating farther on this very difficult subject, I shall proceed to enumerate very briefly the different rocks which occur in the southern portion of the district under consideration.

I have, on a former occasion, given a section of the strata on the route from *Baroda* to *Udayapur*, and this, in addition to Captain DANGERFIELD's account, and the section of Captain STEWART, in the *Bombay Literary Transactions*, renders it unnecessary for me to say much on this branch of my subject.

The rocks, then, which principally occur are chloritic and argillaceous schists, —greenstone, —greenstone schists, —quartz rock, —and more rarely, though still in considerable abundance, micaceous schist, granitic rocks, —gneiss, —with occasional beds of serpentine and marble. These rocks pass into each other by insensible degrees, so that it is often difficult to say to which class particular specimens ought to belong. On a general view of the subject I may state, that the argillaceous rocks are more abundant on the southern than in the northern portion of the tract under consideration, while in the latter the granitic rocks, with their accompanying gneisses, micaceous schists, and hornblende rocks, greatly preponderate, —quartz rock being very abundant throughout the whole of Central India. In the neighbourhood of the *Dhábar* lake, granitic rocks, with gneiss, hornblende rocks, &c. are discovered, and a similar formation, but of no great breadth, may be traced from this, running on a northerly and southerly, or south-easterly direction, through a considerable extent of country, the line of continuity being interrupted by the occasional occurrence of rocks of a different nature. This formation may very probably be a continuation of the granitic rocks which occur at *Wari*, in *Guzerat*, as described by Captain STEWART.

The granites have a structure generally intermediate betwixt large and small grained. Their characteristic color is red, but they sometimes occur small grained and of a grey color—the color in the red varieties depending on the felspar which usually exhibits a foliated fracture, and which is, generally speaking, the most abundant ingredient. It is sometimes associated with quartz alone, and this variety is generally large grained, the quartz being white and semi-transparent. Passing into the last the common granite is found, and the mica in this varies from nearly *black*, through olive green, to silver white. I have never met with it in this portion of the country in large plates. To this last, again,

hornblende is frequently superadded, and this either replaces the mica, or occurs associated with it in the same mass. Besides the above, talcose and chloritic granites also occur,—and these have occasionally scales of mica disseminated through them. The close grained grey granites are generally composed of mica, quartz and felspar, the last of which is sometimes *granular*.

The gneisses are also very generally of a reddish color, and this last class of rocks seems to pass into the waved sienitic gneiss, described in a former paper, which passes again into a hornblende rock, with which felspar, of a grey color, is frequently associated. This last passes into pure hornblende rock, and into hornblende schist. In all rocks where hornblende is abundant, and where felspar is associated with it, the latter is almost universally of a grey or whitish color, and a specimen will be hereafter alluded to which was broken from the junction of a hornblende rock approaching to sienitic granite, and a granitic rock with which minute grains of epidote is associated, in which the felspar acquires a redder tint in proportion as it is removed from the hornblende. This might arise from the coloring matter having had a greater affinity for the hornblende than the felspar, when the *original constituents* of these minerals were in a *state to enable such affinity to be exerted*.

We shall now turn our attention to the QUARTZ ROCK of this district, a rock which appears to me to be of first rate importance. In treating of the Geology on the route from *Baroda* to *Udayapur*, we have had occasion to describe immense beds of this formation, and it is of very abundant occurrence throughout the whole of Central India. This rock varies much in its texture in different situations. The purest variety exists in the form of a white semi-transparent rock either stratified or very indistinctly so, and sometimes exhibiting large unstratified beds, very frequently of

the regular *prismatic form* alluded to in describing the granites. It either occurs compact or granular, the grains varying from the minutest possible size to the size of a bean, and many of the varieties have a *saccharine aspect*. These latter exactly resemble, in their external appearance, the very pure white, fine grained, primitive dolomites, with which however they cannot, for a moment, be confounded; but it was not without minute examination, and subjecting them to the influence of the common native furnace, that I could persuade myself that some of the varieties were quartz, —they might possibly be confounded with some of the varieties of compact felspar. They are slightly translucent. The quartz rock frequently appears as if composed of a congeries of large angular masses closely cemented together. This appearance, in a great measure, depends on the seams and cracks which traverse the beds in every direction, dividing them into a number of square and rectangular portions. In this last variety, numerous embedded masses of a nearly transparent quartz, forming a coarse rock crystal, occur, indeed almost the entire of some of the beds exists in this last form.

The quartz, on one hand, passes into micaceous schist, which passes again into gneiss, granite, &c.; and on the other, into argillaceous schist. It first becomes distinctly stratified. It acquires a greyish color, and this color gradually deepens; it then becomes more slaty in its texture; mica is sparingly distributed through its substance, and it appears to pass into a harder and more durable variety of argillaceous schist. In many situations, but more especially in the boundary ranges of the valley of *Udayapur*, the connecting link betwixt these two last mentioned series is a rock of a fine granular texture, which occurs distinctly stratified, and has a structure inclining to slaty. Its color is nearly white, and it can with difficulty be scratched by the knife. On exposure, it acquires a beautiful dendritical appearance at the surface, and it passes into a

rock of nearly a similar nature, but which is softer and has a greater proportion of alumina associated with the silica, which last, however, appears to be the most abundant ingredient. This rock greatly resembles, in its structure, the fine grained freestones; but it occurs in strata highly inclined alternating with the other rocks. It is seen passing both into the more compact quartz rocks and the argillaceous schists.

A very common variety of quartz rock in this district appears in the form of a compact, fine grained rock,—translucent, or translucent at the edges,—of a bluish color, with sometimes a tint of red, and capable of being split into layers of from half an inch to nearly a foot in thickness, and in the deep ravines in which this portion of the country abounds, many sections of the strata of this rock may be observed. From the compactness and durability of its structure,—from the regularity of its stratification, and the nearly vertical position of these strata—the surface of these crags is often perfectly smooth and perpendicular. This variety occurs abundantly in the boundary ranges of the valley, and forms the entire of the hills which skirt the *Udayaságar* lake, running south, till it is succeeded by the granitic rocks and gneiss of the neighbourhood of the *Dhúbar* lake. It is also of very abundant occurrence throughout the whole of the southern portion of the district under consideration. It is the hornstone and columnar hornstone of Captain DANGERFIELD.

Ferruginous quartz is also abundant, and the color of this varies from very dark blackish red to a red of a light shade. The quartz rocks, too, sometimes approach to the nature of the millstone grits, and many of them have a tendency to assume, on exposure, a globular form, the surface of these exhibiting a concentric laminary structure. This is particularly the case with those varieties which have a small quantity of felspar associated with them. Indeed, these last seem, in many instances,

to pass into an *imperfect variety of granitic rock*. In this the quartz is associated with a considerable proportion of felspar, generally of a reddish color—an instance of this kind was alluded to in page 38, and I shall have occasion to describe in my next a series of rocks of this kind, which occur in the boundary ranges of the valley. They are composed of reddish colored felspar and quartz,—the felspar having a tendency to be decomposed and crumble down on exposure. They are sometimes fine grained, but more frequently intermediate betwixt fine and large grained—they have, generally speaking, a porphyritic structure, and pass insensibly into the quartz rocks.

It is not my object in this sketch to trace the different rock formations throughout their whole extent, or to define correctly their limits. I merely wish to give a general account of their structure and mode of occurrence, and as opportunities occur, hereafter to give a more detailed account of individual portions of this extensive tract. To trace correctly the different quartz rock formations, would be a work of great difficulty. They occur very extensively distributed and associated with all kinds of rock. I may remark, however, in a general way, that a belt of quartz, exhibiting, in many situations, craggy and precipitous hills, seems to skirt this great primitive district through a large extent of country, and to separate it from the newer rocks described at the commencement of this paper. Captain STEWART's section exhibits it interposed between the sandstones and the granitic rocks on the route from *Mow* to *Baroda*,—west of the sandstones near *Chitor* I have also seen it, and north of this last mentioned city it still makes its appearance. It is probably a continuation of a similar formation which occurs in the neighbourhood of *Sáhar*, forty miles from *Biana*, in the *Bharatpur* district, which extends to the south and north of the former place, and which is bounded to the east by the rocks described in a former paper as

occurring at and near *Biana*. The hill fort of *Sáhar* is situated on an isolated rock of this formation. The hill exhibiting an exactly similar shape to those of *Nakúm*, (see section p. 50.) The rocks of this belt I look upon to be the last formed of the great primitive series of Central India, and they deserve more than any others which I have seen to be considered as belonging to the submedial class.

It would appear that the cause which operated in forming the strata of this district was liable to great, *though not to sudden*, alterations,—that the purest variety of rock formed was quartz,—that to this, under peculiar circumstances, other ingredients were added,—sometimes mica alone, sometimes felspar, hornblende, &c., and sometimes alumina, and that this forming cause had a constant tendency to *revert to that state* to which pure siliceous rocks owed their formation,—the original constituents of felspar, argillaceous rocks, &c. being occasionally superadded to those of the siliceous rocks, modifying their external structure, color, &c. according as the former were *more or less abundant*. I here merely state the broad principle without speculating on the nature of this forming cause. The granitic rocks might have been first formed, and the forming cause might have gradually acquired that state to which the pure siliceous rocks owed their formation; this cause might undergo another *gradual* alteration, and thus, from the *superabundance* of one or other of the original ingredients, constituting the solid strata of the earth, various modifications of these might have been produced.

The wonderful powers of chemical affinity,—powers to which it is impossible to assign any limits,—and the changes which result from the absence, or presence, or superabundance of particular ingredients, all of which circumstances modify the attractions and repulsions of the original atoms of bodies for each other, are well known to every Chemist, and it

is surely not going *too far* to say, that these causes might have operated most powerfully in modifying the external characters of rocks.

The ARGILLACEOUS SCHISTS, with their accompanying GREENSTONE SCHISTS, GREENSTONES, and CHLORITE SCHISTS, next claim our attention. The argillaceous schists vary much in their texture. From the siliceo-argillaceous schists, which pass into the more slaty varieties of quartz rock, to a schist of a loose friable texture, we have a regular gradation. Several varieties of argillaceous schist have been described before (see paper on the Geology of the route from *Baroda* to *Udayapur*,) together with the rocks with which they are associated. They are very generally of a dark grey color, and many of them approach to the nature of roofing slate. These last are generally of a bluish color—other varieties are also bluish, but are soft and friable with a slightly greasy feel, the color depending on copper—others are black, making an indistinct mark on paper, while others are light grey, buff, fawn colored, and greenish. The latter pass sometimes into chlorite schist, and at others into greenstone schist. Many of them have mica disseminated through their substance, and these last pass into micaceous schist, while others have a *distinct greasy feel*, and the latter, in one situation, I have seen passing into well marked talcose schist. This last rock does not appear to be of abundant occurrence in this district. The instance alluded to was discovered in the boundary ranges of the valley. The talco-argillaceous schists, or those which have a distinct greasy feel, are, however, common. To the above, the *calc: schiste* of the French may be added, which occasionally presents itself. Thin laminæ, of a whitish colored limestone, in small patches, being disseminated through a basis of argillaceous schist. This forms a calcareo-argillaceous schist.

The argillaceous schists frequently resemble the greywacke schists, as commonly described, and these again pass into greenstone schist and

greenstone. The latter, in many situations, perfectly resembles the greenstones of the overlying trap formation, and frequently contains imbedded calcareous spar, as do also the greenstone schists. The greenstones, and less frequently so, the greenstone schists exhibit a porphyritic structure. The low hills of the valley of *Udayapur* consist of a series of alternations of argillaceous schist and greenstone, greenstone schist, &c.—and the greenstones occur both stratified and in regular prismatic beds, alternating with other strata. There is another rock which frequently occupies the place of the greenstones in alternations of this last mentioned rock with argillaceous schist, the relative position to the argillaceous schists being similar. It appears to be *greenstone*, which has *lost its hornblende*, and is principally composed of felspar of a greenish grey color, associated with a proportion of quartz, greater or less in different situations. A similar occurrence is described as taking place in Wales—this rock exhibits a porphyritic structure, and somewhat resembles the clay stony porphyry of JAMESON. It is found abundantly in the valley.

Several of the argillaceous schists, especially those which pass into greenstone and greywacke schist, as well as the greenstone schists themselves, are capable of being cut into long masses of various thickness and breadth,—and also into flat slabs. Some of these masses are fourteen feet in length, and are used in place of beams to support the flat roofs of the numerous rectangular buildings of Hindu origin, which abound in this portion of India. The flat slabs are used as roofing stones, and the series of pillars on which these flat-roofed buildings are supported, are also solid masses of the same rocks. These are often fancifully carved. Indeed, these stones are used in place of beams in all the buildings, whether flat-roofed or domed, in this part of the country, excepting in such as are built of marble.

The above series of rocks form by far the greatest part of the southern portion of the district under consideration, and numerous veins of quartz make their appearance in *all* the rocks here observed. Beds of serpentine are also found, generally in low situations, and this last sometimes appears to pass into chlorite schists. Of it tables, and various ornamental works, are fabricated. It occurs unstratified. Marble is not very abundant, but is here and there observed in beds in micaceous schists, gneiss, &c. It is generally large grained, and I believe is also found, though rarely so, associated with the argillaceous schists. A considerable bed of this rock occurs near *Satumbher*.

The strata are highly inclined, sometimes almost vertical. Their general dip is to the N. E. or E. N. E., this is particularly the case with the granitic rocks, &c. They frequently, however, dip to the N. W. and to the intermediate points between N. E. and N. W. sometimes too, though rarely so, they are found inclining in a south-easterly direction. The strata of the softer varieties of argillaceous schist are sometimes considerably distorted, and the more slaty varieties of this last mentioned series frequently exhibit a waved aspect. No change, excepting that of a gradual passage of the one rock into the other, is observed *at the junctions of the various alternating strata*. In some instances where the transition is abrupt, and in alternations of greenstones and argillaceous schists, this is frequently the case. After minute examination, I could perceive no *alteration or change of structure* in either of the rocks at their points of junction—the line of demarkation being well marked.

The number of simple minerals in this district appears to be small. Rock crystal, amethyst, but not of any value,—garnets, which last occur in the micaceous schists, gneisses, &c., iron pyrites, which is found occasionally in the argillaceous schists, calcareous spar,—schorl and

actynolite, with other minerals usually found associated with the granitic rocks, complete the list. The metals are iron, copper, and lead, with which last silver appears sometimes to be associated. The iron is very abundant in many situations—and there are several founderies for this metal. Copper does not appear to be very plentiful, but may be detected in many of the soft bluish varieties of argillaceous schist. On digesting a mass of this rock in nitric acid, a steel rod plunged in the fluid acquires a coating of copper. There is a lead mine at the village of *Jowar*? twelve miles south of *Udayapur*, which occurs in a series of alternations of quartz rock and argillaceous schist, and it is said that a considerable proportion of silver was found combined with this metal, which was worked at one time to considerable advantage. Were this country properly explored, I have no doubt but that many rich mines might be discovered.

A country where such a diversity is perceived in the nature of the rocks must, necessarily, present a bold and striking appearance, and in accordance with this diversity, we observe a corresponding difference in the shape of the hills,—the harder and more durable rocks appearing, as it were, to penetrate through the substance of the softer, and rising in the form of peaks, denticulated ridges, &c. From the extensive distribution of the quartz rock, and from its hard and durable nature, many very striking appearances are exhibited. It is sufficiently obvious, when a hard rock is associated with one of soft and less durable nature, that in the course of time the former will occupy the highest position, whatever might have been its original situation. This, then, is the case when the quartz rocks are associated with the softer argillaceous schists. The latter gradually crumble away, and leave the former occupying the summits of the hills, and presenting different aspects according to the nature of the quartz and the breadth of its

beds. A very common appearance throughout the whole of Central India is derived from this source. I allude to the occurrence of a thin bed of quartz, seldom more than a few feet in thickness, often only a few inches, which runs along the ridges of the hills throughout the whole extent, forming a sharp angle from which the darker colored argillaceous schists slope on either side. Where the quartz beds are thicker, they often rise abruptly to the right and left on rugged, nearly perpendicular cliffs—often presenting the appearance of ruined fortifications and castellated walls rising from the slope of the hills, and exhibiting altogether the most striking scenes which I have ever witnessed. Numerous perpendicular cliffs also present themselves—the perpendicular face of these cliffs, being on the opposite direction to that on which the strata dip. This is particularly observed in hills formed of the distinctly stratified quartz rock, described in pages 80 and 81, and even more strikingly so, when the above rock alternates with argillaceous schist, and on the direction in which the strata dip the hills are often almost destitute of soil, the sun being reflected from the bare surface with fearful intensity, while on the other side the slope, especially in such cases, when the outcroppings of argillaceous schist are observed, is covered with jungle, above which the cliffs just described, are seen rising abruptly. The ridge-shaped hills are, however, the most common, and these are generally formed of distinctly stratified quartz, the strata being arranged in a nearly vertical position. From the sharpness of the angle and the regularity of the outline which the summits of many of these hills present,—these summits appear in the distance to be flat, and the deception is increased by their frequently assuming the form of a truncated cone. In the latter instance the sharp ridge still exists. It is continued for some distance in a direction parallel to the horizon, and then suddenly slopes on either side at a very acute angle. We have also denticulated ridges, the hills exhibiting this appearance being generally composed of siliceo-

argillaceous schists, and the more durable varieties of argillaceous schist, while peaks, often of fantastic form, are seen rising above the surrounding hills. The softer argillaceous schists occur generally forming round backed hills and gentle swells. While the granites, hornblende rocks, which approach to primitive greenstones, &c. are frequently arranged in large globular heaps piled on each other, as if artificially. The pure white quartz rock, too, frequently assumes the form of low rounded swells, entirely destitute of soil, and resembles, in the distance, extended plains covered with snow.

The form of the hills in this district is constantly liable to change—during the rains immense blocks of the harder rocks are detached, and the process of decomposition in the softer and less durable varieties is carried on with amazing rapidity. Hence its rugged and broken aspect, and this ruggedness is yearly increased by the channels which the hill torrents are constantly forming for themselves.

That this district has been subjected, at various periods of time, to those violent convulsions of nature which have operated with greater or less force in every quarter of the globe, there can be no doubt. The deep valleys and rugged ravines—the sliding off or sinking of the strata forming the whole sides of mountains, a narrow ravine only separating the detached portions from the parent hills,—all which appearances are frequently observed in this portion of the country, are sufficient to prove this; but let not a love for the marvellous lead us beyond the limits which reason has prescribed. The difference observed in the nature and durability of the rocks, and their capability or the reverse of resisting the decomposing effects of the atmosphere, of the mechanical effects of water, &c. will account for very many of the appearances described, and in a climate like this these causes operate with amazing force.

In this district too, we can trace appearances which have probably resulted from the LAST GREAT FLOOD to which our planet was subjected, in the huge blocks and rolled masses which frequently present themselves detached from the beds in which they originally occurred, and at a great distance from them. The sharp angular appearance of these fragments indicate that they were not long exposed to the action of water. Immense tracts present themselves strewn with angular blocks and masses of the white quartz, which has been described as being characterised by its numerous seams and cracks, and which, owing to this circumstance, was peculiarly liable to be detached from its original position; and in many situations I have observed heaps of the masses of this rock piled upon each other as if artificially, and resting on low rounded hills, composed of a similar variety of quartz. It is impossible, on witnessing these, not to conclude that higher hills, formed of this rock, originally existed in such situations, and that all that now is left of these are the heaps just alluded to, which still remain to mark the spot where mountains have existed before—and we cannot fail to perceive the ruins of these mountains in the masses of quartz which strew the country far and near.

It is impossible, from facts of this nature, to arrive at any certain conclusions regarding the direction from which this flood came. Cross currents and a thousand other circumstances must be taken into consideration; but from the general position which these detached fragments occupy, I am inclined to believe that it came from the west or north-west.

GEOLOGY OF THE NORTHERN PORTION.—We shall now proceed to describe, as briefly as possible, the Geology of the northern portion of the district under consideration. The great difference in the external appearance of the country betwixt the northern and southern portions, has already

been pointed out, and my observations are confined to that part of it which lies east of the central range.

With regard to the central range itself, in the neighbourhood of *Udayapur*, it is formed of the distinctly stratified quartz rock described in page 62, —which alternates with argillaceous schists, &c. and exhibits sharp and denticulated ridges, peaks, &c. As we proceed north, the granitic rocks make their appearance with their associated gneisses, micaceous schists, and hornblende rocks. These are found at no great distance to the north of *Udayapur*, and on the most northern portions of *Mewar*, in the *Ajmer* district, and where this range borders on *Marwar*, they are the only rocks met with. From the large plates of mica, which are brought from the latter portion of the district, we may judge of the nature of the rocks of this range to the north.

The country lying betwixt this range and the belt of secondary rocks, which form the *Chitor* range, and from thence extend west for a short distance, is generally level, and from its surface rise several detached hills and hill ranges. The nature of the rocks in this portion of the country will be understood from the accompanying section of the strata which occur on the route from *Nimach* to *Mertah*, which last is situated about a mile and a half from the base of the central range. These rocks cross the country in an oblique direction, the strata running nearly from N. W. to S. E.

Proceeding north from *Mertah*, we have a continuation of the rocks described in the explanation of the section as occurring at and near *Mertah*. In these, the associated felspar is frequently *granular*, and the last sometimes occurs nearly pure, in which case it forms the *white stone* of WERNER. This, however, is rare. Beds of semi-transparent quartz also

occur, and in some instances this rock assumes an almost schistose aspect. When this last is broken in a direction parallel to the schistose structure, minute scales of mica may be frequently observed, which divide the mass into a number of thin parallel bars. The mica cannot be observed in the unbroken mass, or in the cross fracture, and the bars are sometimes so thin that the rock assumes a *fibrous* appearance.

When felspar occurs associated with hornblende, the former is generally white or grey, and in some specimens of sienitic granite, I have observed that the felspar, when exposed at the surface, has acquired a reddish tint, and it is only on breaking the mass that we discover its real color. In one hand-specimen, broken from the junction of a hornblende rock approaching to sienitic granite, and a close-grained granitic rock, through which are disseminated minute yellowish green specks of a mineral, which appears to me to be *Epidote*,—the felspar of the hornblende rock is grey, while that of the other is reddish; the felspar acquiring a redder tint in proportion as it is removed from the hornblende. Through many of the granitic rocks which occur here, the minute green specks just alluded to, are disseminated. When these rocks are exposed to a powerful heat, the green color of these specks is converted into a black, and a similar mineral occurs intimately associated with a rock which appeared to me, on first seeing it, to be a variety of a schistose quartz. It has a specific gravity, however, varying from 2.9 to 3.4, or even 3.5, according as this green mineral is in larger or smaller proportion. This last appears to be translucent at the edges, to have a fracture slightly foliated, and something of a fibrous structure. Its hardness is intermediate, between that of felspar and quartz—it is rather brittle, and before the blow pipe, or when exposed to a powerful heat, it is converted into *black* or *dark brown scorix*. Its color is light yellowish green, and sometimes

greyish green. It appears to be a variety of Epidote, and the rock just described occurs in considerable abundance.*

In the series of rocks under consideration, chlorite appears frequently to occupy the place of the hornblendes, and the rocks containing this mineral have, sometimes, a structure approaching to that of gneiss,—the chlorite being arranged in nearly parallel, interrupted layers, alternating with layers of the other ingredients. This last rock is distinctly stratified, and passes into chlorite schist. Chlorite also occurs in minute quantity in many of the rocks approaching to the nature of white stone.

In the neighbourhood of the central range, in this part of the country, we have numerous detached ranges, and the surface of the country, on proceeding towards *Náth'dwára*, becomes rugged and uneven, exhibiting a mammillary belt, in which are situated several deep and small valleys. The rocks observed are different modifications of granitic rocks, alternating with hornblende rocks. *Náth'dwára* (famous for its temple, which is one of the most sacred in India, with those of the *Vaishnava* persuasion,) stands about twenty-four miles north, and a little to the east of *Udayapur*. It is situated on the inner slope of a group of hills of a rugged aspect, and which group is connected with the mammillary belt above alluded to. The rocks which occur there are argillaceous schists, containing a large proportion of mica, and these pass into micaceous schist, which alternates with quartz rock passing into gneiss. The *Banás* river, skirts this group. For about four miles east of *Náth'dwára*, we have still numerous detached hills and groups, and the country is broken and rugged,—we then enter the level plains of *Mewar*.

* In addition to this mineral, I suspect that Schiller spar occasionally occurs. Associated with the quartz is a rock which has a specific gravity of about 2.8. It is so intimately blended with the quartz, however, that I could not determine with any degree of precision respecting its nature.

In the district north of *Náth'dwára*, including the most northern portions of *Mewar*, and the *Ajmer* and *Jaypur* districts, we find granitic rocks, gneisses, micaceous schists, and hornblende rocks, with occasional beds of marble and serpentine—while the argillaceous rocks are rare. But before describing these, it may be as well to give, in this place, a short description of the Geology of the country on the route from *Náth'dwára* to *Kankarauli*, distance of about nine miles north, and slightly east. This portion of the country acquires importance from the marble quarries which abound in it.

Proceeding then north from the *Banás* river, the route running parallel to, and at no great distance from the central range, the country exhibits a mammillary aspect, and to our right stretch out the level plains of *Mewar*. The first rocks which present themselves, are micaceous schists approaching to argillaceous schists, which appear to pass, on one hand, into argillaceous schists, with which a large proportion of mica is associated, and on the other, into gneiss, generally of a schistose structure. Small thin laminae of a white limestone, occasionally occur in patches in the schistose rocks, forming a variety of the *calcschiste* of the French. The preponderating rock, however, is micaceous schist, in which occur beds of quartz and hornblende rocks.

On arriving at *Kankarauli*, several low ranges of hills are observed. The Lake, for which its sacred city (for it, as well as *Náth'dwára*, is the seat of a Gosain of the Vaishnava persuasion) is famous, may be about fourteen miles in circumference. It is skirted on two sides by these low ranges, and on the other sides the water is confined by two *bunds* of large extent, and there is another *bund* which blocks up a broad ravine which separates two of the ranges just alluded to.

It is in these ranges that the marble formation of *Kankarauli* occurs. On the side to which the strata dip, the acclivity is gentle ; but in the opposite direction, they present bluff crags which overhang the lake. The marble occurs in distinctly stratified beds. In a hill examined, the first rock which presented itself was micaceous schist, composed of quartz and mica, the last in large proportion, and in silvery plates of considerable size. Dipping under this, occurred a thick bed of marble, the outcroppings of the strata making their appearance throughout the whole extent of a low ridge skirting the lake. Under this again, a micaceous schist, of a more stony aspect than the last, occurred. This contains a considerable proportion of associated felspar, and passes into a gneiss of a slaty structure, which is succeeded by a sienitic granite, or rather a hornblende rock, with which is associated a very large proportion of hornblende. All these rocks are distinctly stratified, and dip at an angle of about 45° --the dip being southerly, a little inclined to the east.

The marble which I had an opportunity of examining, was coarse-grained and crystalline. One variety was nearly pure white, while another was greyish white, the last being rather of a closer texture,—both were slightly translucent at the edges, and in their structure they frequently approached to *slaty*. This marble is a primitive *dolomite*. It is dissolved slowly, but entirely in nitric and muriatic acids, with *slight effervescence*, and contains a considerable proportion of carbonate of magnesia, associated with the carbonate of lime. The marble quarries from which all this portion of India is supplied, occur a few miles from this town, and near another lake of smaller size, called the *Rajnagar*. This marble is more compact and fine-grained than the variety just described, and is associated with a similar variety of rocks.

The Bunds which are constructed of marble, have a very imposing appearance, and numerous *flat-roofed* buildings, supported on pillars,

exhibiting very richly carved specimens of Hindu architecture, adorn the principal of these. These buildings are completely covered with figures of the Hindu deities, carved in alto relievo. The strata of this limited portion of the country generally dip in a southerly direction, while those in other situations, to the N. S., and in the same parallels of latitude, generally dip to the N. E.

The ranges run in a direction parallel to the direction of the strata, and the micaceous schists and gneisses of this series generally contain embedded garnets.

With regard to the other portions of this district, north and east of *Kankarauli*, I may remark, in a general way, that in it are probably discovered, in any abundance at least,—the oldest rocks which occur in Central India, and these may very probably dip under the argillaceous rocks of the south. The whole of which last series would appear to repose against micaceous schist, passing insensibly into gneiss, the last passing again into granite. Immediately to the north of *Kankarauli*, we enter a perfectly level plain, which is continued to the base of the central range, which range rises abruptly from its surface—and, supposing a line drawn in a north-easterly direction from *Kankarauli* to the fort of *Banára*, situated forty-two miles north of *Chitor*, we have to the N. W. of this line a perfectly level plain, at the surface of which the primitive strata constantly appear—and this plain is, in many situations, bounded by the horizon, not one single detached hill or range making its appearance till we approach the hill groups at and near *Banái*, which lies nineteen miles S. E. from *Nasirabad*.

To the S. E. of this line we have also level plains, but from the surface of these rise numerous detached hills and hill ranges—and a

range of considerable extent stretches in a south-westerly direction, from the fort of *Banira*. The first rocks which present themselves are micaceous schists, in which the mica is abundant, and in plates of considerable size; in these are embedded garnets. Beds of quartz, and a micaceous schist, approaching to argillaceous schist, are frequently met with—and the latter of these rocks is more abundant towards the south. For a very considerable distance to the north of *Kankarauli*, and from thence east to *Bhilwara*, situated thirty-four miles north of *Chitor*, the micaceous schists still preponderate, and they alternate with hornblende rocks and quartz. In the neighbourhood of *Bhilwara*, we observe an extensive series of alternations of this kind; and the hornblende rocks, which occur in great abundance, exist in the form of hornblende schist,—hornblende rock, and hornblende rock approaching to sienitic granite.

Proceeding north, the granitic rocks preponderate, and the range of hills, on the termination of which to the north, *Banira* is situated, is entirely composed of granite. The granites of this range are various, and the different varieties alternate with each other,—some of the beds being stratified, and others assuming a regular prismatic form. One variety is a very fine-grained grey granite, of a crumbling nature, easily affected by the atmosphere, and, in its partially decomposed state, exactly resembling a sandstone. Another variety is a granite, in which quartz and felspar occur in large angular concretions, the quartz being white and semi-transparent, and the felspar being nearly opaque, and of a milky white color—with these a very small proportion of mica is associated. This last rock was traversed by veins of felspar, or rather adularia, of a beautiful pearly lustre. Another variety of granite also occurred, in which the *mica*, of a dark olive color, *was distinctly crystallized, as were also occasionally the quartz and felspar*. The last variety is large granular. The hills of this range are low, and they do

not rise higher than three hundred feet above the level of the plain. Their shape is round, approaching to conical.

On leaving *Banira*, we enter the level primitive plain, described in pages 79 and 80—and this plain is, in many situations, almost literally covered with garnets, giving to the face of the country a red aspect. The precious and common garnet both occur. The former is small, and seldom in perfect crystals—the latter is large, often the size of a hen's egg, and is regularly crystallized in the usual manner. The rocks are still different modifications of granitic rocks, with which are associated occasional beds of hornblende rock, and hornblende schist—the first passing into sienitic granite. Some of the granites are composed of quartz and felspar alone, the latter being milky white, and the former semi-transparent. These are arranged in large angular concretions, and have at a little distance quite the aspect of calcedony. This rock is stratified, and felspar in thin seams, which run parallel to the strata, occurs in it. This felspar is translucent, of a slightly greenish color, and easily breaks into fragments of a rhomboidal form. It exhibits, in some small degree, the play of colors so remarkable in the Labrador felspar. Besides the above granites, composed of quartz, bright flesh-colored felspar and steatite occur,—the last ingredient being sometimes wanting; common granite is also found—in this the mica, as seen in the mass, is of a brass yellow color, but when placed between the eye and the light, is of a greenish straw color. Schorl is occasionally met with in these granites, and in their structure they vary from fine grained to large grained.

The above rocks are continued till we approach *Banái*, nineteen miles south-east of *Nasirabad*, when we now again perceive numerous detached hills and hill groups—and rocks containing hornblende preponderate. The rocks heretofore met with have, generally speaking, been regularly

stratified, and the strata appearing to cross the country obliquely, and running nearly north-west and south-east.

Banáí is situated at the base of a group of hills, which, though they appear smooth and conical in the distance, are found, on nearing them, to be entirely destitute of vegetation, the rock of which they are composed having a tendency to assume the form of large globular, or rather *columnar* masses, which are piled on each other,—one of these masses frequently occupying the very summit of the hills, and presenting a very striking appearance. A small fort tops a low, conical, and precipitous hill, or rather crag,—the fort appearing to rise from the rock, and to be a continuation of it.

The rock composing this group of hills does *not* appear to be stratified. In its texture it inclines to small granular. It is composed of grey felspar, quartz, and black shining hornblende, and has a structure similar to that of gneiss, the hornblende being arranged in slightly interrupted nearly parallel layers, alternating with layers of quartz and felspar intimately mixed. Small garnets occur disseminated through this rock, and in many situations it has a perfect gneissy structure. It may be classed with the sienitic gneisses.

Proceeding from this last place towards *Nasírabad*, we have alternations of granitic rocks, with hornblende rocks and gneiss, all these passing into each other—hornblende being a common ingredient in all. Large rounded heaps of these rocks are seen piled upon each other near the route, and they do not occur stratified, but in large and broad prismatic beds, running in the usual direction of the strata of this district. The route from *Banáí* to *Nasírabad* is in a direction nearly parallel to, but a little to the west of, the direction in which these beds run, and we frequently meet with the same rock for the distance of one or two miles.

The country surrounding *Nasirabad* is bleak and desolate. The cantonment itself is situated on an elevated plain, exhibiting, in almost every position, the out-croppings of the vertical strata; and the soil, where there is any soil, is seldom deeper than a few inches. The surface rises into several low rounded swells, destitute, or nearly so, of vegetation, and in the neighbouring country several detached hills and hill groups are observed. To the west and north-west, the central range of hills is seen to stretch. It presents a bleak and rocky outline. It rises abruptly from the plains, and in some situations exhibits peaks, frequently of considerable altitude,—some of them, in the neighbourhood of *Ajmere*, rising about one thousand two hundred feet above the level of the plain. In this portion of the country there is scarcely a single tree observed.

The rocks which occur are different modifications of granitic rocks, alternating with each other in narrow beds, and these are associated with gneiss, micaceous schist, and hornblende rocks. All these pass into each other by insensible degrees. The hornblende rocks pass into greenstone, and also exist in the form of pure hornblende rock and hornblende schist, with both of which felspar occurs associated, and these last pass into sienitic granite. The gneisses are generally schistoses, not waved, and the granites are very various—sometimes large grained, but more generally small grained. In the above, beds of pure white quartz occur,—these last frequently rising into hills completely destitute of vegetation. The quartz, exhibiting a saccharine structure, described in page 62, is found here, and other varieties are semi-transparent. Some also exhibit an almost schistose structure, and are similar to those described in page 73. Indeed, the whole series of rocks which occurs at *Nasirabad*, is very similar to that described as being met with at and near *Mertah*. The rocks of this series are, generally speaking, stratified, and the strata run in a direction N. W. and S. W. probably skirting, through a large extent of

country, the western limits of the formation described at *Banái*, and exhibiting in their course different appearances. The granitic rocks found in the neighbourhood of *Shapoorá*, fourteen miles east of *Ban'ra*, are probably a continuation of this series, while a continuation of the *Ban'ra* rocks may probably be discovered in those to the west of *Nasírabad*.

Proceeding east from *Nasírabad*, in the direction of *Biana*, we pass, in the first instance, through the same bleak and desolate country—the rocks every where appearing at the surface. We have still alternations of granitic rocks and hornblende rocks, with numerous low rounded swells, composed of pure white quartz, large masses of which latter strew the line of march. The granitic rocks lose, at a short distance to the east of *Nasírabad*, their stratiform structure, and frequently appear at the surface in the form of immense lenticular masses, often many yards in diameter, the superior flattened surfaces of which only protrude; and we also observe the piled up heaps of globular masses above alluded to. This formation is obviously a continuation of that observed at *Banái*. Proceeding east as far as *Bambolí*, about thirty miles distant from *Nasírabad*, we have a continuation of a similar variety of rocks, but micaceous and chlorite schists now occasionally make their appearance; the granites, however, preponderate, and in these the felspar is the most abundant ingredient. It is frequently of a crumbling nature. Among other varieties of granite which occur near *Bambolí*, there was one of a very beautiful appearance composed of quartz-hornblende, the last in very small proportion—flesh-colored felspar, and green mica, and in this rock were imbedded portions of a semi-transparent, nearly white, felspar of a rhomboidal form, giving to the mass a porphyritic structure. Numerous detached hills occur in this neighbourhood. They are all very low—some exhibiting the above described appearance of globular heaps piled upon each other—others are smooth and conical, while others are peaked.

Still proceeding in the same direction, about half way betwixt *Nasirabad* and *Biana*, we perceive the two parallel ranges of hills described in page—, and between which ranges our route lies. These ranges seem to terminate to the west in a number of detached hills which rise here and there in the line which the ranges would have followed had they been continued. Some of these detached hills are conical, others are round, while others are occasionally peaked. The rocks are still granites, some of them containing imbedded actinolite, and with others steatite and chlorite occur associated. Gneiss and micaceous schist are also observed, and the last, as we proceed east, becomes very plentiful. Many of the specimens of gneiss have a zoned aspect, parallel layers of red felspar being observed in these, alternating with layers of quartz, &c. and this last rock, in some situations, passes into quartz, the connecting link being a rock composed of parallel bars of quartz, separated from each other by plates of mica. At a small village called *Gherwási*, about eighty-six miles from *Nasirabad*, occurs a low hill, composed of micaceous schist, with subordinate beds of gneiss and granites, into both of which it appeared to pass. I here found specimens of a variety of *fibrous* quartz of a slightly reddish tint—the fibres were arranged in a manner similar to those of fibrous gypsum, and it occurred imbedded in the rocks in oblong portions of small size, the superior and inferior surfaces of which were slightly convex.

Proceeding in the same direction, the above rocks are still observed, and small grained granites, composed principally of quartz and felspar, with which occasional minute scales of mica are associated, preponderate as we proceed east. Beds of micaceous schist and quartz are also met with,—and the rocks just alluded to are succeeded by the quartz rock formation, in the centre of which stands the hill fort of *Sáhar*, or *Onsha Sáhar*—see page 65. Felspar, in small proportion, occasionally occurs associated with this quartz.

The hills of the parallel ranges which bound to the right and left, the plain over which the line of march lies—are low. Their summits very frequently present a sharp ridge, the acclivity on each side being rapid, and this ridge exhibits an even and uniform line. Sometimes, too, the summits are flattened, and their outline altogether is exceedingly monotonous, the even line which these summits exhibit, being frequently continued for miles without interruption. This is more particularly observed in the most eastern portion of the *Jaypur* district, while to the west denticulated ridges occasionally occur, and sometimes, though rarely so, low conical peaks present themselves. The hills which rise from the plain, especially those of the quartz formation, are more abrupt and precipitous.

Proceeding from the hill fort of *Baníra* N. E. towards *TONK*, we have still level plains with their detached hills and hill ranges, and these hills become more numerous as we proceed east,—several small ranges too, are seen running on a north-easterly and south-westerly direction. The country is generally covered with soil, from which occasionally protrude granitic rocks, &c., and these are probably a continuation of the rocks observed at and near *Nasírabad*, and to the east of this cantonment; and about twenty-six miles N. E. from *Baníra*, we observe several hills composed of granite rocks, gneiss, &c. in large unstratified beds, the large lenticular masses described in page 84, together with the hills formed of the globular masses so often alluded to, being frequently perceived. This last formation is probably a continuation of that perceived at *Bandi*, &c.

A village called *Tora*, is situated at about twenty-four miles S. W. of *TONK*, and stands near the base of a considerable range of hills, which runs in a north-easterly and south-westerly direction. The hills of this range exhibit ridge-shaped and denticulated summits, and the preponderating rock is gneiss, on one hand passing into micaceous schist, and on the other into

granite. In some of these the felspar exists in the form of a soft earthy substance, (*kaolin*,) sometimes it is of a reddish color, and at others it is greyish white. The last is frequently granular.

The country surrounding **TONK** is characterised by its numerous detached groups, and the hills often rise into peaks of fantastic form, denticulated ridges, &c. Many of them are entirely destitute of vegetation, and a sharp craggy peak, of a very striking appearance, and crowned by a domed building, overhangs the city. The rocks observed are granitic rocks passing into gneiss, quartz being a very abundant ingredient in these.

Proceeding N. E. from **TONK** towards *Sowáli*, situated in a pass in the most southern of the two parallel ranges, alluded to in page 85, and distant twenty miles S. W. from *Sáhar*, the detached hills are still numerous, and many of them are crowned by a strong-hold. The windings of the *Banás* river are frequently crossed, and the rocks gradually pass into quartz rock, approaching to gneiss, with which hills of micaceous and chlorite schists are associated.

Five miles to the S. W. of a small village called *Bopái*, which stands about twenty-six miles S. W. of *Sowáli*, is a hill fort, of a very imposing appearance. The small detached range, on the highest point of which it is situated, appeared principally composed of quartz of a white color. The lower and central regions of the hills were covered with stunted jungle; the rock then suddenly took a more perpendicular direction, and rose by a very steep acclivity, till, with the slope on the other side, it formed a sharp denticulated ridge, frequently rising into needle-shaped points, and exhibiting a peculiarly *bristled* aspect. The upper regions of these hills were entirely destitute of vegetation. Many other of the hill ranges

presented similar appearances, and we had also the usual ridge-shaped hills, and some were conical.

On approaching *Sowáli*, these detached ranges were still very numerous, and the secondary ranges, described in page 56, were seen passing off in pairs from the range, at the base of which *Sowáli* is situated. I need scarcely add that the word “*secondary*” has no reference, in this place, to the rocks of which the hills are formed, but is merely used as a relative term to express the connexion of these ranges with the greater range. These secondary ranges, then, are not continued far, but terminate a short distance to the south. Their summits present various appearances,—some are flattened or slightly rounded, and are bounded on either side by nearly perpendicular smooth crags which rise abruptly from the slope. Others are ridge-shaped, while others are slightly denticulated.

The rocks which present themselves are small grained granitic rocks, the quartz and felspar being by far the most abundant ingredients, and these are associated with micaceous schists and quartz rocks. Succeeding these, the quartz formation of *Sáhar* occurs.

The above is all the information which I can give relative to the Geology of this district. My communication has already been extended beyond the limits which I at first proposed for myself, and my concluding observations shall be few and general.

In the northern portion of this district, I stated that beds of marble and serpentine are found, excepting, however, the marble formation of *Kankarauli*. I have not had an opportunity of examining these, and shall therefore content myself with remarking, that marble appears to be plentiful in the northern portions, both of *Ajmer* and *Jaypur*.

Regarding the metals of this district I can say but little. During the past cold season, I had proceeded as far as *Nasirabad*, for the purpose of examining the *Ajmer* lead mines; but the sudden calls of duty obliged me to return to *Udayapur*, when I was on the very point of setting out on my intended excursion. I can, therefore, give no additional information to what is already known respecting these mines,—and I must be satisfied with remarking, in a general way, that iron, copper, and lead, with which last silver has occasionally been found associated in small proportion, are the only metals which have as yet been found in this district. Several specimens were shown me as ores of antimony. These were, however, well-marked galena. There are several iron founderies in this district, and this last metal appears to be very abundant in the quartz rock formation. Copper mines, too, have, I believe, been worked near *Mandal*, in *Mewar*.

Several simple minerals have been mentioned as occurring in the granitic rocks, &c. ; and in one variety of granite was observed a mineral which appeared to me to be Saussurite.

The depth of the wells in the primitive portions of Central India appears to depend, in a great measure, on their being near, or at a distance from—the large lakes which abound in this district, and the remark first made by *SHAH BABER*, (see *LEYDEN*, and *ERSKINE*'s translation of his life,) who appears to have been a wonderfully intelligent observer of nature, I have found to be perfectly correct. This remark is, that in the apparently dried-up courses of rivers and nullahs in India, water is universally found close upon the surface, and that, even during the hottest periods of the year, it is only necessary to dig a few feet through the sand to reach it. We cannot but agree in the reflection made by this monarch upon stating the circumstance ; viz. that it presents an instance of one

of the many bountiful arrangements which Providence has made to supply the wants of its creatures. Many of the wells at *Nasírabad* are eighty feet deep, and are bored through the solid rock—the water in these is generally *brackish*—and is impregnated with saline ingredients. The hill fort of *Hamírgher*, situated twenty-one miles north of *Chítor*, is remarkable on account of a well which has been bored, with infinite labour, through the solid rock from the summit to the very base of the low hill on which the fort is situated. This well is nearly two hundred feet deep.

During the rains, springs of water may be seen, in many of the hilly districts, issuing from the rocks at the surface.

In the north of *Ajmer* and *Jaypur*, the water is bad and brackish. In the southern districts it is excellent; and the only foreign ingredient which I have as yet detected in it is carbonate of lime, which sometimes exists in considerable proportion. A quantity of carbonic acid gas, in a free state, must, of course, exist in these waters, to enable them to hold the carbonate of lime in solution.

With regard to the Geology of the primitive portion of the district to the west of the central range, I can say nothing. My specimens from the *Serooe* district are as follows, and these indicate a similar variety of rocks to those which we have described as occurring to the east of this range: 1st, a rock composed of pure black shining hornblende without intermixture; 2d, nearly the same as the above, but with associated felspar in small proportion; 3d, a sienitic granite, approaching to primitive greenstone; 4th, a granitic rock, composed of flesh-colored felspar, with a distinct foliated fracture, quartz in much smaller proportion, and of a white color, and steatite—the last in very small quantity, and in other specimens of the same rock entirely wanting—this granite is very large

granular; 5th, a sienitic granite intermediate between small and large granular, and principally composed of grey felspar, with which is occasionally associated quartz and hornblende, the last in minute proportion—a soft reddish iron ochry-looking substance occurs disseminated through this variety; 6th, a very compact primitive limestone, with a texture approaching to that of calcareous spar; 7th, a limestone, or marble of a whitish color, consisting of a congeries of minute grains, which appear to the naked eye rounded, but which seen through a microscope have an imperfect crystalline structure, exhibiting sharp angles, &c.—through this rock is disseminated minute scales of a dark colored mica; 8th, a limestone somewhat similar to the last, of a cream-color, composed of similar grains in a very loose state of aggregation, so that it crumbles into a fine calcareous sand almost on being handled. Through this rock are disseminated scales of an olive-colored mica, and a portion of it being thrown into nitric acid, the calcareous grains were completely dissolved with brisk effervescence, while there remained as a residuum, the scales of olive-colored mica, a few minute grains of quartz, and two other minerals, the nature of which I do not altogether understand.

One occurred in small cylindrical grains, or rather six-sided prisms, the lateral planes of these not being very well marked, but at the same time sufficiently distinct to entitle them to the appellation of crystals. They are about the size of a grain of rice, are slightly translucent, approaching to opaque—of a white color and silky aspect; they are soft, and easily crumble between the fingers into a fine silky looking powder. Before the blow pipe they acquire a more opaque degree of whiteness, and they do not appear to be affected by acids. Their specific gravity does not seem to exceed $2^{\circ} 00$, but from the smallness of the size of these crystals, and from their lightness, I could not ascertain this point with precision, not being possessed of scales sufficiently delicate.

The other is of an emerald-green color, translucent or semi-transparent. It occurs in grains or crystals of nearly a similar form to the last, but these are frequently flattened. It also occurs in small irregular grains which assume no distinct form. Like the first, it exhibits a very fine fibrous structure. It has a shining vitreous aspect—it is soft, so as to be scratched by the knife, but it is harder than the other; it is exceedingly brittle. Its fracture appears to be foliated, and its specific gravity does not exceed that of the last. When exposed to the flame of the blow pipe, it acquires a darker color, and becomes opaque and friable.

The above minerals appear to be more allied to apatite, than to any other substance with which I am acquainted. The friend to whom I am indebted for my specimens informed me, that the rock in which these are found occurs very abundantly on the route from *Udayapur* to *Seroi*. A specimen of this rock I have the pleasure to forward.

I have only further to add, that I have found imbedded in *kunker*, in the valley of *Udayapur*, several varieties of primitive rocks, which I have not yet been able to discover in situ. Of these I may mention one. It has a waved appearance, is close grained, almost compact, and consists of white quartz and a dark colored limestone, arranged in waved alternating layers. It effervesces strongly with acids. A specimen of this rock I have also the pleasure to forward.

N° 2



N° 1



N° 3



R. Smith Calcutta

Common? Lith. Fr. 1829

IV.

ON THE

FORMULÆ FOR CALCULATING

AZIMUTH

IN TRIGONOMETRICAL OPERATIONS.

BY CAPTAIN G. EVEREST, F. R. S. M. A. S., &c.

Surveyor General and Superintendent of the Great Trigonometrical Survey of India.

IN offering to the notice of the Society the accompanying paper, I beg to explain that my object is to put on record certain formulæ, connected with the method generally employed in the Trigonometrical Surveys of England and of India, for determining Azimuths.

Those of my readers, who are familiar with this subject, will remember that the method in question consists in observing the difference of Azimuth between a fixed lamp of reference and some circumpolar star, generally α ursæ minoris, at the time of its greatest distance on the east or west side of the meridian.

But to accomplish this, the actual time of the phenomenon, and frequently the altitude, require to be known, and as it is advisable to have these elements prepared for the occasion at leisure, the latitude of the place is sometimes drawn from data to which the final corrections have not been applied, and the polar distance is perhaps taken from a catalogue which succeeding observations have shown to be imperfect.

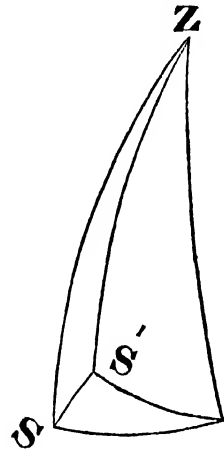
The second part of this paper is intended therefore to furnish formulæ, whereby the observer may introduce the required corrections without

undergoing the toil and loss of time which would attend a formal recomputation of the whole set of observations, and it will be remarked that the second hypothesis will also enable him to compute, by means of differences, a series for many nights in succession with quite as much correctness as if entire quantities had been used ; for in that case he has only to calculate the elements for the first night, and substitute for the value of $d b$ the increment or decrement of polar distance, the other terms being virtually constant.

It has always, however, been an evil complained of in operations of this kind, that by limiting the case to the actual time of maximum Azimuth, the powers of the observer are much curtailed, because he cannot take more than one observation on the same night.

If observations, taken intermediately between the culmination and the time of the greatest Azimuth, were to be computed with reference to the meridian, it would be indispensable to employ large quantities, and the operose formulæ of Spherical Trigonometry, which would not only be laborious, but would not give so much accuracy as the method of eliciting the correction by means of differential terms.

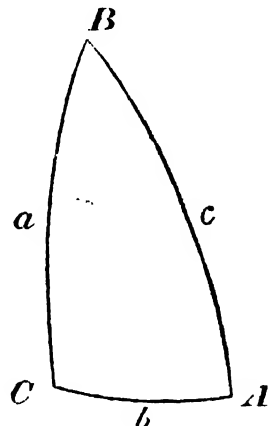
I shall explain this better by a reference to the diagram in the margin, wherein the two Arcs ZS , ZS' are drawn very near to each other, the angle PSZ being a right angle, and it will be seen immediately how much more easily and accurately the angle PZS' may be found by computing the partial angle SZS' , and deducting it from PZS , than by direct computation of the entire angle PZS' itself.



I have introduced, in the first part, the ordinary rules for computing the elements at the time of maximum, with the view that those, for whose use these formulæ are intended, may not need a

reference to first principles, but have the subject in a complete state before them; and this must be my apology, should it be objected to me that I have presumed to intrude on the Society with propositions strictly elementary.

In any spherical triangle ABC if the sides b and c are constant, the sines of the angles B and C will attain their greatest values contemporaneously.



For the general equation is

$$\sin B = \sin C \cdot \frac{\sin b}{\sin c}$$

in which the term $\sin B$ is obviously a maximum when $\sin C$ is a maximum; *i. e.* when $C = \frac{\pi}{2}$ or 90° .

If, therefore, A represent the Pole, B the Zenith, and C the place of a circumpolar star; when the Azimuth which is represented by the angle B is a maximum, the angle of position at C will be a right angle: in that case, therefore, we have

$$1st. \cos A = \tan b \cdot \cot c \dots \dots \dots (\alpha)$$

$$2nd. \sin B = \frac{\sin b}{\sin c} \dots \dots \dots (\beta)$$

$$3rd. \cos a = \frac{\cos c}{\cos b} \dots \dots \dots (\gamma)$$

But A represents the hour angle, or portion of sidereal space passed through between the instant of transit and that of maximum Azimuth;

c , the complement of the Latitude of the place of observation, or $c = \frac{\pi}{2} - \lambda$;
 b , the polar distance of the star; B the angle of Azimuth, and a the Zenith distance: consequently, if t^s denote the seconds of sidereal time, the above equations are transformed to

$$\text{1st. } \cos (15.t^s) = \tan * \text{'s Pol. dist} \times \tan \lambda$$

$$\text{2nd. } \sin * \text{'s Azimuth} = \sin * \text{'s Pol. dist} \times \sec \lambda$$

$$\text{3rd. } \sin * \text{'s Altitude} = \sec * \text{'s Pol. dist} \times \sin \lambda$$

If t^s be required in mean solar time, it must be diminished in the ratio
 of twenty-four hours to 23 56 4, or if τ^s denote the seconds in mean solar time, then we have $\text{Log. } \tau^s = \text{Log. } t^s + \text{Const. } 1.9983127$.

The corrections are also easily obtained from tables constructed on purpose.

To take an example of this; let the time of the greatest Western Azimuth of the Pole-star be required on the 1th May, 1830, in Latitude $24^\circ 0' 0''$, as also the Azimuth and Altitude at that instant; the Longitude being 78° East of Greenwich, and the Polar distance $1^\circ 36' 0''$.

	Hour Angle.	Azimuth.	Altitude.
Pol. dist	$1^\circ 36' 0'' \dots \tan 8.4461103 \dots$	$\sin 8.4159109 \dots$	$\sec 0.0001694$
Lat.	$24^\circ 0' 0'' \dots \tan 9.6485831 \dots$	$\sec 0.0392698 \dots$	$\sin 9.6093133$
Space	$89^\circ 17' 14.''8 \cos 8.0946934$	$\sin 8.4852107$	$\sin 9.6094827$

$$1^\circ 45' 5.''37 \quad 24^\circ 0' 35.''83.$$

$$5 \quad 57 \quad 8.98 \text{ Siderial time.} \quad \text{Refraction} + \quad 0 \quad 2 \quad 9.83.$$

$$22 \quad 16 \quad 3.19 \text{ A.R. } (* - \odot) \text{ at noon.}$$

$$\text{Appt. Altde } 24 \quad 2 \quad 45.66.$$

$$\overline{16 \quad 18 \quad 54.21 \text{ Sid. time}}$$

$$\overline{\quad \quad 2 \quad 40.37 \text{ Corr}^n.}$$

$$16 \quad 16 \quad 13.84 \text{ Mean Solar Time.}$$

Hitherto the two sides b and c have been supposed to be correctly known, but it is not an unusual occurrence that a series of observations is computed for many nights by anticipation, with a Latitude merely approximate, and that when this element comes to be finally determined, corrections must be applied to obviate the effects of errors which may thus have been introduced.

To find these corrections, we must differentiate the equations (α) , (β) , (γ) , with respect to c ; whence we obtain

$$1st. \quad -\sin A. dA = -\frac{\tan b}{\sin^2 c} \cdot dc = \frac{\tan b}{\sin^2 c} \cdot d\lambda$$

$$\therefore -dA = \frac{\tan b}{\sin A. \sin^2 c} \cdot d\lambda = \frac{\tan b}{\sin a. \sin c} \cdot d\lambda$$

$$\text{Whence } -dA = \frac{\tan B}{\sin c} \cdot d\lambda = \tan B. \sec \lambda. d\lambda$$

$$2nd. \quad \cos B. dB = \frac{-\sin b. \cos c. dc}{\sin^2 c} = -\sin B. \cot c. dc$$

$$\therefore dB = \tan B. \tan \lambda. d\lambda$$

$$3d. \quad \sin a. da = \frac{-\sin c. dc}{\cos b}$$

$$\therefore da = \frac{\sin c}{\sin a. \cos b} \cdot dc = \frac{dc}{\sin A. \cos b}$$

$$-da = \frac{d\lambda}{\cos B} = \sec B. d\lambda$$

To show the application of these formulæ, let it be supposed that the parts of the triangle of greatest Azimuth had been computed previously for some nights in succession, with a Latitude deduced from an approximate series of triangles, and that instead of $24^\circ 0' 0''$, as supposed in the

last example, the Latitude was found to be $24^{\circ} 1' 45''$. Then the operation will stand as follows :

	Hour Angle.	Azimuth.	Altitude.
$d \lambda = 105''$ Log 2.02119 Log 2.02119 Log 2.02119			
$B = 1^{\circ} 45'$ Log tan 2.48541 Tan 2.48541 Sec 0.00020			
$\lambda = 24^{\circ} 0' 0''$ Sec 0.03927 Tan 1.64858			
15 A. C. Log	8.82391		
<hr/>			
Corrections..... $0''23$ Log 1.36978 $1''43$.. Log 0.15513 $1' 15''05$.. Log 2.02139			
1st Computn... H. $16^{\circ} 16' 13.84''$	1 45 5.27	24 2 45.66	
Correct values H. M. S. $16^{\circ} 16' 13.61''$	1 45 6.70	24 4 30.71	

It will also sometimes happen in practice, that a series of observations, computed with data drawn from an imperfect catalogue of former years, requires to be corrected in conformity with the superior accuracy obtained by modern observers. In that case we must differentiate the same equations (α) (β) (γ) with respect to the Polar distance b , whence we obtain

$$1^{\text{st}} \dots \sin A. d A = \frac{\cot c}{\cos^2 b}. d b$$

$$\therefore - d A = \frac{\cot c}{\sin A. \cos^2 b}. d b = \frac{\cos c}{\sin c. \sin A. \cos^2 b}. d b$$

$$\text{Or} - d A = \frac{\cos c}{\sin a. \cos^2 b}. d b = \frac{\cos a}{\sin a. \cos b}. d b = \cot a. \sec b. d b$$

$$2^{\text{d}} \cos B. d B = \frac{\cos b. d b}{\sin c}$$

$$\therefore d B = \frac{\cos b}{\cos B. \sin c}. d b = \frac{d b}{\sin A. \cos \lambda}$$

$$3^{\text{d}} - \sin a. d a = \frac{\cos c. \sin b. d b}{\cos^2 b}$$

$$d a = \frac{\cos c. \sin b}{\sin a. \cos^2 b}. d b = \cot a. \tan b. d b.$$

These formulæ, computed similarly to the former examples, will stand as follow. Suppose that (instead of $1^{\circ} 36'$) the polar distance had been $1^{\circ} 35' 34''$, but that all the observations had been already computed with the former of these values. Then we shall have $d b = -26''$.

$$\begin{aligned}
 d b &= -26'' \dots \dots \text{Log } 1.41497 \dots \dots \text{Log } 1.41497 \dots \dots \text{Log } 1.41497 \\
 b &= 1^{\circ} 36' 0'' \dots \dots \text{Sec } 0.00017 \dots \dots \text{Tan } 2.44611 \\
 \left(\frac{\pi}{2} - a \right) &= 24^{\circ} 0' 36'' \dots \dots \text{Tan } 1.64878 \dots \dots \text{Tan } 1.64878 \\
 15 \text{ A. C. Log.} &\dots \dots 2.82391 \\
 \Lambda &= \dots \dots \text{Cosec.} \dots \dots 0.00003 \\
 \lambda &= \dots \dots \text{Sec } \dots \dots 0.03927
 \end{aligned}$$

Corrections, $\dots \dots 0.77 \dots \text{Log } 1.88783 \dots 28''.46 \dots \text{Log } 1.45427 \dots 0''.32 \dots \text{Log } 1.50986$

1st. Compd. values, $16 \ 16 \ 13.81 \dots \dots 1^{\circ} 15' 5''.37 \dots \dots 24 \ 2.45.66$

Correct values, $\dots \dots 16 \ 16 \ 14.61 \dots \dots 1^{\circ} 44' 36.91'' \dots \dots 24 \ 2.45.34$

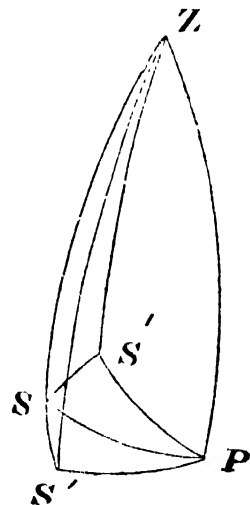
In these computations, the correction is applied to the altitude with an opposite sign to that resulting from the formula, as due to the zenith distance, the rationale of which will be evident. The formulæ will evidently shorten such operations considerably, because there is no necessity for more than five places of decimals, unless the variations are very large, and thus, if we retain all the quantities but the variation of b , we may compute a set of observations for many nights in succession, by merely finding the variations which are occasioned in the other parts.

In the work on the great Meridional Arc of India, which the Court of Directors did me the honor to have printed, the principle is examined (vide page 89,) of determining for how long periods some of the principal circumpolar stars of the Greenwich Catalogue may be considered as stationary in Azimuth; and it is therein shewn that, during the $2' 3''.6$ preceding and subsequent to the Maximum, the variation in Azimuth of the Pole Star is only $0''.25$, a quantity less than the powers of our best instruments can be considered capable of detecting under ordinary

circumstances—similarly β Ursæ Minoris and β Cephei, the two stars in former editions of the Nautical Almanack nearest the Pole, have $1' 23''$ and $1' 12''$ for their stationary periods.

It must, however, be remarked, that the hypothesis, on which that enquiry is conducted, is not rigorous; for it is therein taken for granted that the same vertical circle will pass through the upper and lower positions of the star at equal lapses of time before and after the Maximum, an assumption which, though perfectly admissible for the end therein proposed, will not bear to be much extended: as for instance, suppose it were required to determine what would be the effect on the Azimuth, if instead of the precise instant of the Maximum, the observation were made at any time before or after that phenomenon.

To this end let PSZ be the polar triangle right angled at S , and let S' be the place of a star before or after arriving at S —Draw the Arcs of great Circles PS' , SS' , ZS' , and then since PSS' is Isosceles, if a perpendicular were drawn from P on SS' it would divide that side, and also the angle at P into two equal and similar parts, so that if δP , δZ denote the variations of the hour angle and Azimuth, we have



$$1st. \quad \tan PSS' = \cot \frac{1}{2} \delta P \sec PS$$

$$2d. \quad \sin \frac{1}{2} SS' = \sin \frac{1}{2} \delta P \sin PS$$

Hence, because of the right angle at S , we have $\sin ZSS' = \cos PSS'$ and $\cos ZSS' = \pm \sin PSS'$ and therefore the general equation becomes (vide Woodhouse's Trigon. page 157—3d edition).

$$\tan \delta Z = - \frac{\cos PSS'}{\cot SS' \cdot \sin ZS + \sin PSS' \cdot \cos ZS}$$

$$\text{But } \cos ZS = \frac{\cos PZ}{\cos PS} - \frac{\sin \lambda}{\cos PS}$$

$$\text{And } \tan ZS = \frac{\cos Z}{\cot PZ} = \frac{\cos Z}{\tan \lambda}$$

$$\therefore \sin ZS = \frac{\cos Z \cdot \cos \lambda}{\cos PS}$$

$$\begin{aligned} \text{Consequently } \tan \delta Z &= \frac{\cos PSS' \cdot \cos PS}{\cot SS' \cdot \cos Z \cdot \cos \lambda + \sin PSS' \cdot \sin \lambda} \\ &= \frac{\cot PSS' \cdot \cos PS}{\sin \lambda} \cdot \frac{\cos Z}{\tan SS' \cdot \tan \lambda \cdot \sin PSS' + 1} + 1 \\ &= \frac{\cos^2 PS \cdot \tan \frac{1}{2} \delta P}{\sin \lambda} \cdot \frac{1}{\tan SS' \cdot \tan \lambda \cdot \sin PSS' + 1} \end{aligned}$$

Where the upper sign is used, when the star is nearer the Zenith, and the lower, when it is further removed from the Zenith than in the position of maximum.

If in the former of these cases, which occurs in the Western Elongation before, and in the Eastern after arriving at the maximum, we put

$$\left(\frac{\tan SS' \cdot \tan \lambda \cdot \sin PSS'}{\cos Z} \right)^{\frac{1}{2}} = \sin \theta$$

$$\text{Then } \tan \delta Z = \frac{\cos^2 PS \cdot \tan \frac{1}{2} \delta P}{\sin \lambda} \cdot \tan^2 \theta$$

$$\text{Or } \delta Z = \frac{\cos^2 PS \cdot \tan \frac{1}{2} \delta P \cdot \tan^2 \theta}{\sin \lambda \cdot \sin 1''} \text{ in seconds of a great circle}$$

Likewise in the latter case, which takes place when before the maximum in the Eastern and after the maximum in the Western Elongation, if we put

$$\left(\frac{\tan SS' \cdot \tan \lambda \cdot \sin PSS'}{\cos''} \right)^{\frac{1}{2}} = \tan \theta'$$

$$\text{Then } \tan \delta Z = \frac{\cos^2 PS \cdot \tan \frac{1}{2} \delta P}{\sin \lambda} \cdot \sin^2 \theta'$$

$$\text{And } \delta Z = \frac{\cos^2 PS \cdot \tan \frac{1}{2} \delta P \cdot \sin^2 \theta'}{\sin \lambda \cdot \sin 1''} -$$

This method is quite rigorous, but it is rather more operose than the nature of the case usually requires: before, however, proceeding to simplify the formulæ, it may *not* be worth while to give an example of each of the cases above adverted to, and to that end let it be required to determine what would be the correction to be applied to the Azimuth, if instead of the actual instant of maximum on the 4th May 1830, the star had been observed thirty minutes before or after that occurrence.

This computation will be most conveniently arranged according to the following form, premising that, in deducing the tangent of a very small arc from its sine, and vice versâ, the easiest method is to add or subtract the Log. Secant, and that to deduce the tangent of an angle from the sine of half the angle, the easiest way is to add to the latter the Log. of 2, + 3 times Log. Secant; as is evident from the following consideration:

$$\tan 2 \theta = \frac{2 \cdot \tan \theta}{1 - \tan^2 \theta} = 2 \tan \theta \cdot (1 + \tan^2 \theta + \tan^4 \theta, \&c.)$$

$$\therefore \tan 2 \theta = 2 \sin \theta \cdot \sec \theta \cdot (1 + \tan^2 \theta) = 2 \sin \theta \cdot \sec^3 \theta$$

EXAMPLE.

 To find $Tan PSS'$ and $Sin PSS'$
 $\frac{1}{2} \angle P (= 15' \text{ in time}) = 3^\circ 45' 0'' \dots L. Cot \dots 1.1834706$
 $PS = 1^\circ 36' 0'' \dots L. Sec \dots 0.0001694$
 $PSS' \dots L. Tan \dots 1.1836400$

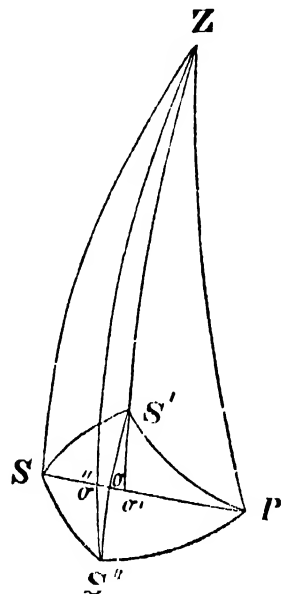
 To find $Sin \frac{1}{2} SS'$ and $Tan SS'$
 $\frac{1}{2} \angle P = 3^\circ 45' 0'' \dots L. Sin \dots 8.8155985$
 $PS = 1^\circ 36' 0'' \dots L. Sin \dots 8.4459409$
 $\frac{1}{2} SS' \dots \left\{ \begin{array}{l} L. Sin \dots 7.2615394 \\ 3. Corr's L. Sec \dots 0.0000021 \end{array} \right\}$

Log of 2. 0.3010300

 $\dots L. Sin \dots 9.9990698$
 $\dots SS' \dots L. Tan \dots 7.5625715$
 $Sin Z = 8.4852107 \dots L. Sec \dots 0.0002028$
 $\lambda = 24^\circ 0' 0'' \dots L. Tan \dots 9.6485831$
 $2) \quad 7.2104272$
 $8.6052136 \quad L. Tan \left\{ \begin{array}{l} L. Sin \dots 8.6052136 \\ L. Sec \dots 0.0003528 \end{array} \right\} \theta$
 $0.0003528 \quad L. Sec \left\{ \begin{array}{l} L. Sin \dots 8.6055664 \\ L. Tan \dots 8.6055664 \end{array} \right\}$
 $8.6048608 \quad L. Sin$
 $9.9998306 \quad L. Cos PS \dots L. Cos \dots 9.9998306$
 8.6046914
 $7.2093828 \quad Double \dots Double \dots 7.2107940$
 $8.8165294 \quad L. Tan \frac{1}{2} \angle P \dots L. Tan \dots 8.8165294$
 $0.3906867 \quad L. Cosec \lambda \dots L. Cosec \dots 0.3906867$
 $5.3144251 \quad A. C. L. Sin 1'' \dots A. C. L. Sin \dots 5.3144251$
 $1.7310240 \quad Log. 53''.830 \quad 54''.005 \quad Log. \dots 1.7324352$

 Value of $\angle Z$ below. Value of $\angle Z$ above.

It will now be in place to explain how the above formula can be simplified, to which purpose let S' , S'' be two positions of a circumpolar star at equal lapses of time before and after the maximum, so that the angles at P , viz. SPS' , SPS'' may be equal to each other; then if the diagonal $S'S''$ of the Quadrilateral formed by the pole and the three positions of the star be drawn, it will intersect the other diagonal PS at right angles in σ and the two vertical circles ZS' , ZS'' (produced in the former case) will intersect the great circle PS obliquely in two points σ' , σ'' making two very small triangles $S'\sigma\sigma'$, $S''\sigma\sigma''$, each equal and similar to the other and right angled at σ . Now in $\Delta ZS\sigma'$ which is right angled at S , if we denote as before by δZ the variation or $SZ\sigma'$, we have



$$1^{\text{st}} \sin SZ = \cot \delta Z. \tan S\sigma'; \text{ or } \tan S\sigma' = \sin SZ. \tan \delta Z$$

$$\therefore S\sigma' = \sin SZ. \delta Z = \sin P. \cos \lambda. \delta Z \dots\dots\dots (\alpha)$$

$$2^{\text{d}} \cos \sigma' = \sin \delta Z. \cos SZ$$

$$\therefore \left(\frac{\pi}{2} - \sigma' \right) = \cos SZ. \delta Z; \text{ and } \sigma' = \frac{\pi}{2} - \cos SZ. \delta Z$$

$$3^{\text{d}} \therefore \sigma S'\sigma' \text{ or } \angle S' = \cos SZ. \delta Z \text{ ————— (in } \Delta S'\sigma\sigma')$$

$$\text{And since } \tan \sigma\sigma' = \sin S'\sigma. \tan S'$$

$$\text{Therefore } \sigma\sigma' = S'\sigma. \cos SZ. \delta Z \dots\dots\dots (\beta)$$

Again in $\Delta PS'\sigma$ right angled at σ we have

$$1^{\text{st}} \cos \delta P = \cot PS'. \tan P\sigma; \text{ but } \tan P\sigma = \tan (PS - S\sigma)$$

$$\therefore \frac{\tan PS - \tan S\sigma}{1 + \tan PS. \tan S\sigma} = \cos \delta P. \tan PS$$

$$\therefore \tan PS - \frac{S\sigma}{\cos^2 PS} = \cos \delta P. \tan PS$$

$$\therefore S \sigma = \tan PS. (1 - \cos \delta P). \cos^2 PS = \sin 2 PS. \sin^2 \frac{1}{2} \delta P. \dots (\gamma)$$

$$\text{2nd } \tan S' \sigma = \sin P \sigma. \tan \delta P = \sin (PS - S \sigma). \tan \delta P$$

$$\therefore S' \sigma = (\sin PS - \cos PS. S \sigma). \tan \delta P$$

$$\text{Or } S' \sigma = \sin PS. \tan \delta P. (1 - \cot PS. S \sigma)$$

$$= \sin PS. \tan \delta P. (1 - 2. \cos^2 PS. \sin^2 \frac{1}{2} \delta P) \dots \dots \dots (\epsilon)$$

Combining now the equations (β) and (ϵ) we obtain

$$\sigma \sigma' = \sin PS. \tan \delta P. (1 - 2. \cos^2 PS. \sin^2 \frac{1}{2} \delta P) \cos SZ. \delta Z$$

$$= \tan PS. \sin \lambda. \tan \delta P. (1 - 2. \cos^2 PS. \sin^2 \frac{1}{2} \delta P). \delta Z. \dots \dots \dots (\zeta)$$

$$\left(\text{because } \cos ZS = \frac{\cos PZ}{\cos PS} = \frac{\sin \lambda}{\cos PS} \right)$$

and this value of $\sigma \sigma'$ answers for both the upper and lower positions, being subtractive in the former, and additive in the latter, with respect to the mean distance $S\sigma$.

We have, therefore, generally

$S\sigma = S\sigma' \mp \sigma \sigma' \dots \dots$ in which, by substituting the values given in Equations (γ) (α) (ζ) we get

$$\sin 2 PS. \sin^2 \frac{1}{2} \delta P = (\sin P. \cos \lambda \mp \tan PS. \sin \lambda. \tan \delta P. (1 - 2. \cos^2 PS. \sin^2 \frac{1}{2} \delta P)). \delta Z$$

$$\therefore \delta Z = \frac{\sin 2 PS. \sin^2 \frac{1}{2} \delta P}{\sin P. \cos \lambda. \left\{ 1 \mp \frac{\tan PS. \tan \lambda. \tan \delta P. (1 - 2. \cos^2 PS. \sin^2 \frac{1}{2} \delta P)}{\sin P} \right\}}$$

$$= \frac{\sin 2 PS. \sin^2 \frac{1}{2} \delta P}{\sin P. \cos \lambda. (1 \mp \cot P. \tan \delta P. (1 - 2. \cos^2 PS. \sin^2 \frac{1}{2} \delta P))}$$

$$\text{Or } \delta Z = \frac{\sin 2 PS. \sin^2 \frac{1}{2} \delta P}{\sin 1'' . \sin P. \cos \lambda} . (1 \pm \cot P. \tan \delta P) \text{ nearly.}$$

Whence $\text{Log } \delta Z = \text{Log } \sin 2 PS + 2. \text{Log. } \sin \frac{1}{2} \delta P + \text{Log. cosec } P + \text{Log. sec } \lambda + \text{A. C. Log. } \sin 1'' \pm M. \cot P. \tan \delta P. \dots \dots \dots$ Where M denotes the number 0.4342944819, &c. whose Log is 9.6377843, the upper or lower sign being used according as the star is above or below the maximum.

The nature of this last substitution has been shewn in my work on the measurement of an Arc of the Meridian (Page 61) and is simply thus.

$$d(\text{hy. log}(1 \pm x)) = \frac{\pm d x}{1 \pm x} = \pm d x. (1 \mp x + x^2 \mp x^3 + \&c.)$$

$$\therefore \text{hy. log}(1 \pm x) = \pm \left(x \mp \frac{x^2}{2} + \frac{x^3}{3} \mp \frac{x^4}{4} + \&c. \right)$$

$$\therefore \text{Log}(1 \pm x) = \pm M x. \left(1 \mp \frac{x}{2} + \frac{x^2}{3} \mp \frac{x^3}{4} + \&c. \right)$$

in which, when x is very small, the series converge so rapidly that all terms but the first may be omitted, and we get merely

$$\text{Log.}(1 \pm x) = \pm M x.$$

$$\text{Therefore Log.}(1 \pm \cot P. \tan \delta P) = \pm M. \cot P. \tan \delta P.$$

Taking now the elements as in the first of the above instances, viz.

$$PS = 1^\circ 36' 0''; \delta P = 30'; P = 89^\circ 17' 14''.8; \lambda = 24^\circ 0' 0''$$

the computation will be as follows :

To find $M. \cot P. \tan \delta P$

9.63778

9.11943 *Tan.* $7^\circ 30'$

3.09472 *cot P*

6.85193 Log. of \mp 0.0007111

$2 PS = 3^\circ 12' 0'' \dots \text{Log. Sin} \dots$ 8.7468015

$\frac{1}{2} \delta P = 3^\circ 45' 0'' \dots 2 \text{ Log. Sin.} \dots$ 7.6311970

$P \text{ Log. Cosec} \dots \dots \dots$ 0.0000336

$\lambda = 24^\circ 0' 0'' \text{ Log. Sec} \dots \dots \dots$ 0.0392698

Ar. Co. Log. Sin $1'' \dots \dots \dots$ 5.3144251

δZ above $54''.005 \dots \dots \dots$ 1.7324381

δZ below $53''.829 \dots \dots \dots$ 1.7310159

The above computations will shew that the approximate method may be quite as much relied on as the more elaborate one, and it will appear on pursuing the enquiry that, for about thirty-two minutes prior and an equal lapse subsequent to the maximum, the Polar Star only varies one minute of space in Azimuth in the latitude of $24^\circ 0' 0''$.

V.

MEMORANDUM

ON

THE FOSSIL SHELLS

DISCOVERED IN THE HIMALAYAN MOUNTAINS.

BY THE REV. R. EVEREST.

I HAVE ventured to say a few words respecting the Fossils sent down from the *Himalaya* mountains, by Dr. GERARD, because nobody else is about to do so ; and it is a pity that they should remain unnoticed.

In doing this, I shall make no remark upon the general difficulty of identifying fossil shells with recent genera, as that is well known to any one who has ever attended to the subject. But to one who lives at a distance from means of reference, such a difficulty is greatly increased, since, in many cases, he must speak from recollection alone. Upon this ground I must plead for the indulgence of my hearers towards such imperfections as they may observe in this paper—my purpose in entering upon a branch of Geology, not the most familiar to me, will have been answered, if I can induce others to join in a pursuit, which circumstances will no longer permit me to continue.

To begin, then, with the specimens before us, in the relative order of their abundance, we have—

1. *First.* Numerous blocks of a compact greyish silicious limestone, (in some parts passing to sandstone), filled with shells and casts of a small inequivalve, eared bivalve, which do not appear to differ from the small *Pecteus* imbedded in the lias blocks from the Coast of Yorkshire, which we owe to the liberality of Mr. TAYLOR. The shells themselves are changed to a black colour as they are in that formation. As they are mostly mutilated, it is not improbable that other genera may hereafter be distinguished among them. One such I have recognized—a very transverse bivalve, not unlike *Unio*, in external shape—but, as I could only find one cast of it, I have not attempted to give it a name—with this genus of *Pecteus* must be ranged two mutilated specimens, which we have in a dark bluish black limestone, and which are only a variety—possibly only the same shell in a more advanced stage of growth—The generic marks are wanting, but by comparing them with a beautiful English specimen of Mr. TAYLOR's, no doubt can remain as to their identity.

2ndly. Many specimens of an inequivalved bivalve, which has been changed into a white crystalline substance, and from its hardness probably contains much silex. They are imbedded in a hard slate of the same bluish black colour, which is covered with small scales of mica—They appear to belong to the genus *Producta*, and may be compared with a specimen of the same genus, the *Producta Scotica*, in Mr. CALDER's collection, and a plate of the same in URE's *Geology*. They differ somewhat from this species by the greater flatness of the lower valve; but as most of the specimens have suffered from compression, it is difficult to ascertain what has been their natural shape. Besides the larger and more abundant variety of which we have been speaking, there is a smaller one, or rather some casts of one of its valves—the depression in

it is large and deep, and towards the beak appears some trace of a perforation and its operculum.

3rdly. Several pieces of a bluish grey limestone, abounding in a plaited variety of *Terebratula*, and loose specimens of the same. The limestone has imbedded in it some calc spar of a yellowish white colour, and is partly covered with a yellowish earthy powder, of the colour we see in the oolitic countries. The shells themselves differ little from those which are so abundant in the inferior oolite near Bath and elsewhere, and which may be referred to in Mr. CALDER's collection—but without Mr. SOWERBY's *Mineral Conchology* to refer to, it is impossible to add the specific name. These blocks also contain No. 1.

4thly. Many specimens of an equivalve transverse bivalve, transversely striated, and the valves crenulated on their interior margin. Its external shape is similar to that of a short variety of *Unio*, to which it has been referred, but internally it has no lateral teeth, nor any remnant of a lateral ridge; and though the specimens we have are too much worn to shew what the teeth really were, they appear to have been situated directly under the beak. Its flattened and acute beaks, and form approaching to that of a variety of fossil *Trigonia* of Mr. CALDER's, once made me incline to reckon it with that genus. Its shape too a good deal resembles a *Venus*, but its characters are not satisfactorily made out, and I have not access to any plate or specimen with which I can identify it. With these are some larger specimens of a triangular or rather suborbicular bivalve, which, in external shape, resembles a *Venus* or perhaps a *Donax*, but the characters are not distinct enough for me to venture to give it a name.

5thly. Several small very transverse equivalved bivalves, about three-fourths of an inch in length, and of a black colour; they appear to be of the genus *Modiola*.

6thly. Two small specimens of a variety of *Arca*.

7thly. Several specimens of *Ammonites* in black limestone, sometimes filled inside with calcareous spar. There is but one species distinguishable, which appears to differ little, if at all, from one of the English ones of Mr. TAYLOR; but unfortunately I cannot refer to any book for the specific name.

8thly. *Belemnites*—the furrow appears to be rather more distinctly marked than in the English ones.

9thly. *Orthoceratites*, which do not appear to differ from the English ones.

10thly. A cast of a *Patelliform* shell—but whether one of the real *Patellæ*, or the upper valve of one of those species of bivalves, which have sometimes been confounded with them, we have no means of determining. Its shape is conical, and somewhat obliquely curved.

11thly. Two fragments of the back of a testudinous animal, also in black limestone.

We have, then, genera determined—of

BIVALVES.		UNIVALVES.	
<i>Producta</i> .		<i>Ammonites</i> .	
<i>Terebratula</i> .		<i>Orthoceratites</i> .	
<i>Pecten</i> .		<i>Belemnites</i> .	
<i>Modiola</i> .			
<i>Arca</i> .			
		Total, Three Genera.	
Altogether, 5			
Undetermined, 4			
Total, 9			

Testudinous remains of one kind.

Let us now see to what conclusions these genera will lead us.

The three Chambered Univalves are all extinct genera, and the *Nautilus*, the only living analogue to the Ammonite, is wanting.

Of these, the Orthoceratite has usually been considered the oldest, and characteristic of the so-called transition strata.

The Ammonite comes next in age, and occurring sparingly in the transition strata, is deposited most abundantly in the Lias, and the other more ancient of the secondary strata; then becoming more and more rare, as we advance to more recent deposits, it finally disappears in the strata above the chalk, that go by the name of Tertiary.

The species we have, though apparently coinciding with one of Mr. TAYLOR's from the Lias of Yorkshire, is not one of those which has the siphuncle in a raised ridge between two furrows, which are considered as characteristic of this formation. I have several times looked for such among the Salagrams in the *Hindoo* temples, but without success.

The Belemnite is found from the Lias to the Chalk, both inclusive.

On the other hand, the Spiral Univalves, which increase both in number and variety as we approach the more recent formations, are with us totally wanting, nor have we as yet any other indications of such formations.

Of the bivalves, the *Producta* is considered as the oldest genus, and is most abundant in the transition formation. The slate in which it is imbedded, is probably, therefore, a transition slate—the same which is the repository of the Orthoceratite.

The Terebratula, if not identical in species with those of Mr. CALDER, from the lower Oolite, is very similar to them, and totally unlike any from the newer formations.

The Pectens, at least the larger variety, do not appear to differ from the common Scallop which is found recent.

The shell I have called Trigonia, cannot be compared with any fossil specimens we have. The genus is, with one exception, a fossil one.

The generic characters of the Arca and Modiola, are tolerably well marked; but we have neither plate nor specimen from which to identify the species. They are not, however, important.

The testudinous remains seem to point to the Lias, or some of the secondary strata, that being the deposit in which the remains of reptiles occur most abundantly. In strata more ancient than that, they are nearly (if not quite) wanting. It is to be hoped that the spot where these two fragments were found, will be again diligently searched—we must forbear from indulging in too sanguine anticipations—but such a search can hardly fail of rewarding us with some interesting discoveries.

Now, if we consider the Orthoceratite and Producta, as peculiar to one formation, and the rest of our specimens to another, (the Terebratula, perhaps, being common to both) and compare them with the list of Lias fossils, we have,—of Chambered Univalves—two genera the same, out of four; viz. Ammonites and Belemnites—of Bivalves, four genera the same out of eighteen; viz. Terebratula, Pecten, Arca, Modiola. We may now then consider this position as established. *That there exist, in the Himalaya range, strata analogous to the early secondary and transition*

formations of Europe. How far that analogy may be complete or not, must be left to future investigation. But the wonderful similitude which has, as yet, obtained in fossils from different parts of the world, leads us to hope that the principal members of each group will be hereafter supplied. While we are on the subject, however, we cannot so well estimate the real amount of progress we have made in the question, as by recapitulating, on the other hand, the leading names in each division, which are as yet wanting to us.

We have nothing either of Encrinal or Coralline remains, which are so abundant in the transition rocks of Europe, that their absence here seems remarkable. We have none of the extinct order of Trilobites, the presence of which is peculiar to transition rocks.

We have no remains of the two vast marine lizards, the Ichthyosaurus and Plesiosaurus, the bones of which every where mark the presence of Lias, and (I speak from authority in saying) without the discovery of which, we must not attempt to use the term Lias in Indian Geology. We have neither of the three shells, the Ammonites Bucklandi, the Plagiotoma Gigantea, and the Gryphœa Incurva, which are also considered as characteristic of that formation—nor have we any of its vegetable remains, which are both numerous and interesting.

I must now again beg to be excused for the imperfections of this paper, and the great length to which it has been extended.

NOTE.—Since the above was written, SIR CHARLES GREY has kindly put into my hands some specimens he has just received from the same quarter—Mr. JAMES PRINSEP has also favoured me in a similar manner.—They are as follows :

1st. The two former varieties of the shell I have called Producta—a third, which can hardly be said to differ from the Producta Scotica—besides what appears to have been the larger valve of an inequivalved Bivalve resembling Producta—the hinge straight linear; the shell marked with longitudinal furrows and ridges, and a deep depression, as

in that genus, but at the beak is a large angular sinus, with what appears to have been an operculum, and ligament protruding—*Spirifer* !

2dly. *Terebratulites*, the same as the others, and at least two new varieties—both of the plaited kind.

3dly. Repetitions of the Bivalve, I have before spoken of under the third head.

4thly. Another impression of the same patelliform shell, as before mentioned.

5thly. Three broken pieces of a Bivalve shell, greatly resembling the *Inoceramus*, for which I beg to refer to the plates in CUVIER.

6thly. Two casts of Spiral Univalves, which appear to be *Cirrus* and *Helix*. The first may be compared with a *Cirrus* from the chalk, and another from the Oolite formation in Mr. CALDER's collection, so that no doubt can well be entertained as to the name.—The one I have called *Helix* resembles the elongated variety, which is called *Helix vivipara*. It may be compared with the casts in a piece of Petworth marble, which we have. But there are other genera to which it may be ascribed—perhaps *Turbo*, for one of them.

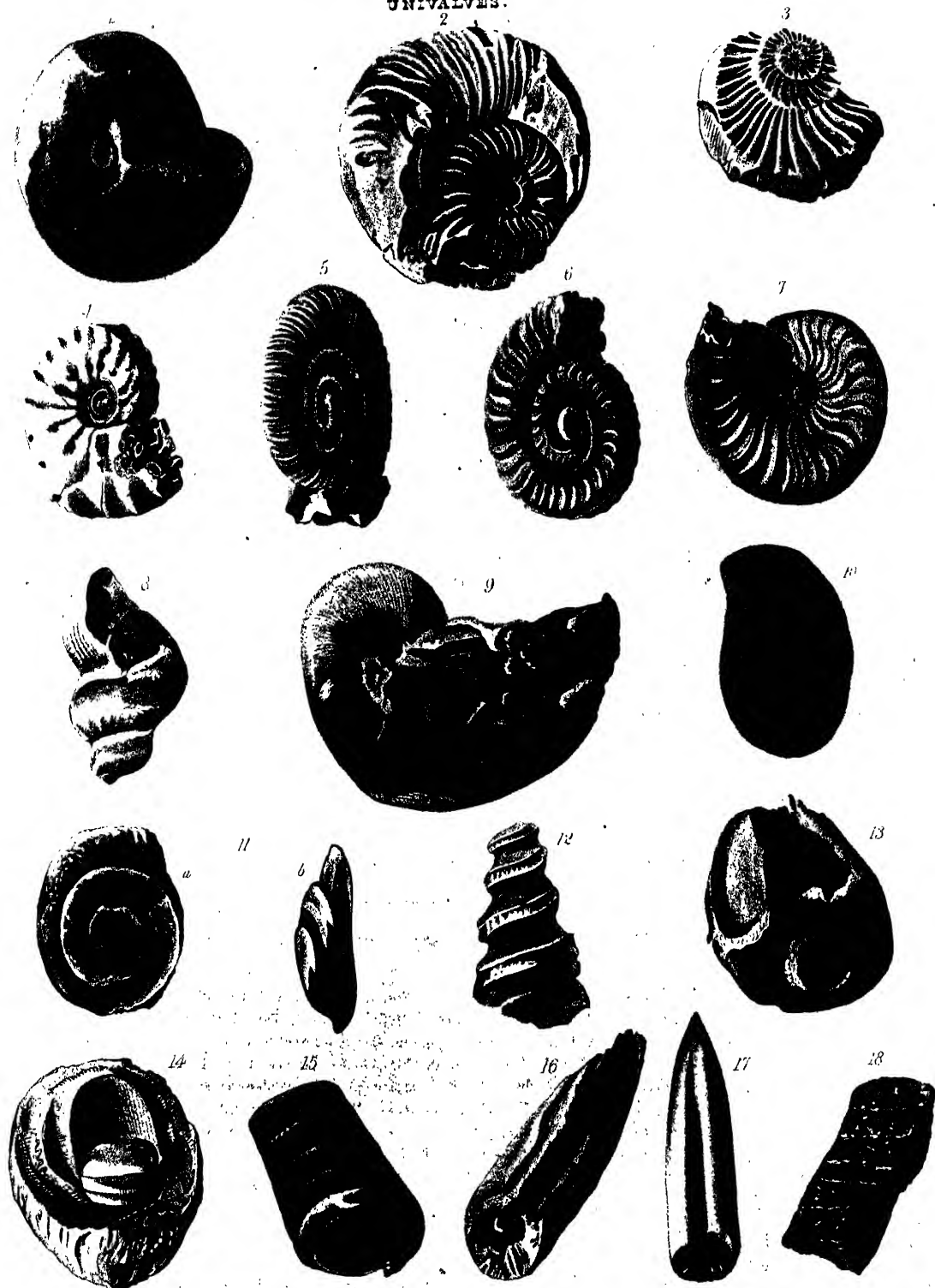
7thly. Two small varieties of *Ammonites*, both much worn, and we have nothing to refer to for the specific name. One of them has the Siphuncle in a raised ridge at the back. There is also an imperfect cast of another variety, which hardly differs from one we have from Mr. TAYLOR, and named in his list as *Ammonites Planicosta*. We have then here three additional genera, *Cirrus*, *Helix*, and *Inoceramus* (?)—besides a multitude of broken and worn impressions of the genera before described, with many nodules of what I believe to be clay ironstone; but I have not yet had time to examine them sufficiently.

Dr. FALCONER has found the specific gravity of some of these nodules to be 3.00, or nearly so; one or two that we have broken, have shewn us *Ammonites* covered with a thin coating of Pyrites. It would always be better for Collectors to split these nodules as carefully as possible, when they are found, instead of sending them down whole.

REFERENCE TO PLATES I. AND II. OF HIMALAYAN FOSSIL SHELLS.

Figure 1. *Orbulite*. Fig. 2. *Ammonite*. Fig. 3. Ditto. Fig. 4. *Orbulite*. Fig. 5. *Ammonite*. Fig. 6. *Ammonite*. Fig. 7. *Orbulite*. Fig. 8. *Helix* or *Turbo*? This Shell is represented rather too large in the drawing. Fig. 9. *Oobulite*. Fig. 10. Cast of a Patelliform Shell. Fig. 11. a, b, *Cirrus*. Fig. 12. *Turritella*? Fig. 13. Undetermined. Fig. 14—15. *Orthoceratites*. Fig. 16—17. *Belemnites*. Fig. 18. Fragment of a *Testudo*. Fig. 19. Fragment of Rock, containing small mutilated *Pectens* and other genera imbedded. Fig. 20—21. *Pectens*. Fig. 22—23. *Producta*. Fig. 24. *Terebratula*. Fig. 25. *Spirifer*? Fig. 26. a, b, c, d, The supposed *Unio*. Fig. 27. *Arca*. Fig. 28. a, b, and c, *Modiola*. Fig. 29. Fragment of an *Inoceramus*?

Himalayan Fossil Shells.
UNIVALVES.



Himalayan Fossil Shells.
BIVALVES.



VI.

ON THE GEOLOGY OF THE PENINSULA.

By LIEUT. S. CHARTERS MACPHERSON,

Madras Survey Department.

THE mountain groups of the Indian Peninsula, which are referrible in their immediate connections to either line of Ghauts, may, in the comprehensive assignment of relations, be regarded as the continuation of the branches, which, depending from the *Himalayan* chain, merge in the plains of the *Ganges* and of *Sinde* respectively. And apart from considerations of geographical analogy, the region which declines on the north of the *Kistna*, from *Hydrabad* towards the *Coromandel* shore, bears similitudes in superficial character to the mountain lines to which it claims affinity. This tract of the eastern declension of the Peninsula is Primary; and as the overlying formation which proximately succeeds it to the Westward, prevails thence continuously to the opposite coast, it presents complete, the series of that division displayed in this parallel. Its plane is eminently traversed by the three hilly ranges of *Hydrabad*, *Condapilly*, and *Beizwarra*, which, with a general north-westerly direction, tend to convergence to the southward. And of these, the Granitic district, with its subordinates, embraces the first, extending to the rise of the

Gneiss facade, which forms the western exposure of the second. The gneiss tract passing to quartz rock, the latter alone constitutes the eastern quarter of the *Condapilly* cluster, while the final range of *Beizwarra* displays an extended deposit of argillaceous schist. The granitic region exhibits in external configuration the ordinary classes of unstratified forms, but with diffuse variations in mineral character, presents no determinate connections betwixt the elementary modifications, and those of arrangement in mass. The rocky environs of *Hydrabad*, chiefly assuming the concretionary structure in prisms, vertically superadded to the bedded form, afford in disintegration a wild assemblage of columnar and cubic fragments: while irregular masses, wasting with spheroidal contours, rise in the same vicinity in isolated mountain domes. The range appears boldly compacted beyond the plain of the *Moussy*, one of the numerous feeders of the *Kistna*, which here reticulate the land, and with slight elementary alteration, a laminal tendency is there combined with the bedded structure. The rock is of quartz and felspar, and usually porphyritic by additional crystals of the latter, and the hue and lustre of the quartz communicate a reddish shade, while neither the rounded nor the prismatically fragmented characters continue eminent. In the course of an easterly transverse valley, the bedded masses persisting upon a cumbrous scale, the contours incline again to asperity and opaque quartz, with hornblende, slightly diffused, predominates in the rock. Beyond *Singaveram* appear extensive masses of magnetic iron ore, now level with the granite of the valley, now irregularly emerging over it, and accompanied by beds of hornblende schist,* usual to this mineral in primary sites. The approach to *Malhapúr* is marked by a general retirement of the hills, and an abraded rock overhangs the hamlet as a large cupola upon the plain, alone affecting departure from the rugged

* By this term varieties of Primitive Greenstone are conveniently comprehended.

outlines around ; and the transection of the range being here completed, its eastern flank extends with well-sustained elevation to the southward, presenting no marked deviation from the lately prevalent characters of form. Rare granitic elevations are scattered over the plain that succeeds, and beyond a tract of arid and incumbered wastes, the surface becomes less difficult, with altered vegetable characters ; hornblende schist alternates with quartz rock in wide undulating courses, and around *Narhailpilly*, the granite is determined to crested summits, by the occasionally vertical disposition of its beds. Towards *Hytepámali*, a surface simply granitic, recurs, and felspar predominates in the soil of *Soria-pet*, while hornblende rock indistinctly stratified, and of massive texture, occasionally appears. The low, bald hills of *Mungal*, *Kamerabanda*, and *Godaweram*, slowly descending through laminar disintegration to the superficial level, are frequently pervaded by veins of jasper, becoming cancellated on exposure: the materials of the rock and vein frequently intermingle, but while fragments of the former appear isolated in the latter, both unaltered and in the grades of assimilation, the venous matter does not occur under reciprocal circumstances in the rock. In some instances also, through combination of the prismatic and bedded structures, the granitic surfaces in this district afford tabular aggregations of short vertical prisms, the rock varying in constitution betwixt gneiss and splintery hornstone. Immediately beyond the village of *Shair Mahomed Pet*, an extensive mass of Hornblende Schist is disposed in the great basis both in the manner of interference and of superposition : and a stream bed displays the course of an emanating vein in which the felspar, having by this accident of locality, passed to some depth to the state of indurated clay, this portion of the rock assumes the constitution and aspect of grey wacke, while the principal bed remains an unaltered greenstone. In the water-course were abundant fragments of compact red iron ore, rolled, with vitreous glaze, with occasional masses of calcareous tufa and of quartz, including

crystals of white and flesh-red felspar, while the granite around deviates widely into constitutional irregularities. In the neighbourhood of *Nandigamah*, primary limestone, chlorite schist, and white slaty quartz rock appear. I could not ascertain the site in mass of the first, a clear limestone, laminated by argillaceous matter. The chlorite occurred foliated with laminar quartz, and scaly with greyish compact felspar and quartz: the former variety being of the usual splendid lustre, and occasionally tending to talcose schist. Beyond the village, hornblende and chlorite schists appeared in frequent alternation, and affording rich cotton moulds: the strata of hornblende were nearly vertical, while the inclination of the chlorite was under 70° ; and a general conformity was maintained, amid the frequent intrusion of granitic veins, until approaching the western face of the *Condapilly* group, which rises boldly interchain-ed near *Partaal*: these tracts are lost in an alluvial plain. The great alluvium of *Ellore*, extending betwixt the Deltas of the *Kistna* and the *Godavery*, here intervenes; and it exhibits a layer of superficial mould resting upon an uniform calcareous deposit which covers an apparently co-extensive bed affording the diamond, and in the neighbourhood of *Partaal*, formerly the most productive of the jewel-bearing spots of *Golconda*. The superficial mould is fifteen feet, the tufaceous bed being from five to six, and the diamond stratum of two feet in average thickness. The obscurity attached to the geognostical history of the diamond, seems rather to result from inadequate investigation in persistent geology, than from the perplexed texture of alluvial connections with which it is frequently associated. Its common matrix in *India* and *Brazil* appears to be a superior sandstone conglomerate, closely affined to the carboniferous rocks, and to this series the transported alluvia which afford the gem may be uniformly assigned. But while its rich depository in this tract does not essentially differ in constitution from the diamond rocks of either hemisphere, it is remarkable that the overlying tufaceous bed, in which the gem has never appeared, is identical with it in materials, only

with the addition of calcareous cement. Pebbles of sandstone, hornstone, quartz, jasper, and flint, with fragments of occasional rocks, epidote, and abundant ferruginous sand constitute the common materials, while both the *Kistna* and its supplementary streams are extensively connected both with the gangue rock of the diamond, and with calcareous tracts. The western façade of the *Condapilly* range is of granitic gneiss, in which the ordinary ingredients are disposed in compact parallelism, and the strata inclined at an angle of about 75° . A detached mass displayed the intrusion of a vein of hornblende, into which the granitic matter entered in the filamentous form, and fragments of ochry iron ore appeared scattered on the surface. A double breach through this and the *Beizwarra* line of hills, here affords to the *Kistna* an escape towards the ocean, the farther chasm appearing in the outline of argillaceous summits. Along the northern base of the first intersection, the gneiss passes by the gradual demission of mica to quartz rock, and upon the side of *Condapilly* the range presents an aspect essentially different from that of its opposite quarter. The summits were there obtusely moulded, their contours broken or minutely serrated, and marked by projections of rifted cliff: the transverse valleys rare, and deeply channelled by mountain streams. Here the outlines are rounded upon scales of great radii, the fragmented aspect is wanting, and the mountain flanks are projected not in precipice or cliff, but in broad smooth convexities, the side shields broken by transverse steppes, and cumbered by dependant verdure. The quartz rock, of quartz and felspar, affords numerous varieties of white, reddish, and purplish hues. It is inclined at an angle somewhat more acute than the subjacent gneiss, while the presence and frequent predominance of garnets in the mass extensively modify its characters, and the almandine or precious garnet, variously tinged, and of superior size and beauty, is found abundantly in the mountain torrents. The range of *Beizwarra* rises with soft outline beyond a succeeding plain. It consists of coarse and thickly fissile argillaceous schist, inclined in texture and

stratification at angles of from 40° to 60° , and through the exuberant presence of unessential minerals, both venous and imbedded, it exhibits modifications of rich variety. The rock is sometimes simply constituted of argillaceous matter with mica and quartz sand: in other portions it is traversed in all directions by filamentous veins of pearl and calcareous spars, and through these often affects the minute contortions proper to gneiss, while veins of spathose iron, and of quartz rock, frequently occur, disposed indifferently to the lines of stratification. To the southward, at *Cottah Mangalagherry*, it embraces, at least from one quarter, an elevated and indistinctly stratified mass of serpentine, which sole example of this rock observed in India, I regret to say, remains unexplored; and assuming to the eastward a more uniform and finely schistose character, it sinks gradually to the ocean level, upon the whole affording the annexed constitutional and Mineral Synopsis.

1. Argillaceous Schist, schistose from the disposition of Mica and Garnets.
2. Argillaceous Schist, laminated by Pearl Spar and Staurolite.
3. Argillaceous Schist laminar, with pink Garnets, Staurolite, and Mica.
4. Argillaceous Schist with Staurolite, Tremolite, and Mica.
5. With Staurolite and Kyanite.
6. Mass of Tremolite with Kyanite Garnets and Prismatic Mica.
7. Quartz vein with Calcareous spar and pink Garnets.
8. Quartz vein with Garnets in ranges, and perhaps Epidote.
9. Vein of Tremolite with Brown spar.
10. Mass of Tremolite, Staurolite, and Pearl spar.
11. White Pearl spar including Bitter spar.
12. Flesh-red Pearl spar.
13. Vein of striated Spathose Iron, with Crystals of Pearl spar.
14. Vein of purplish Quartz with Garnets.

The relations of succession and of magnitude presented by this section may be deemed to exhibit in the extreme, the prevailing principles of Geological Association. The space occupied by granite, with its subordinates, equals three-fifths of the whole, one-fifth of the remainder being allotted to gneiss and quartz rock, while argillaceous schist, upon the superior limit of the series, equals the two last in extension. The transition of granite to gneiss by the intervention of limestone, hornblende, and chlorite, and the apparently direct passage of quartz to argillaceous rock, are in the spirit of somewhat difficult graduation, but the methods of approximation and of transition, here less perfectly displayed, must appear under circumstances of the highest illustrative interest at the points of interference and collision of the series in its southward progress. In respect to economical suggestions which arise upon first regard, the extended plain of *Ellore*, the *Golconda* of proverb, yet remains intact, being but slightly encroached upon in the vicinage of a few hamlets, and if this tract may not again degrade the jewels of the earth, the speculation of glittering increase from it may be entertained. The groups of *Condapilly* and *Beizwarra* are stored with gems of the garnet tribe, and with varied mineral abundance, while the coast hills to the southward appear distributed in rich and nearly continuous successions of metallic deposits. And while nations of the western hemisphere assume a new genius through enterprise, awaked by their mineral advantages, the physical developement of these regions may conduce no less eminently to the interests of science and of wealth.

VII.

ON THE MIGRATION

OF THE

NATATOIRES AND GRALLATOIRES,

AS OBSERVED AT KATHMANDU.

By B. H. HODGSON, Esq.

ACTING RESIDENT AT KATHMANDU

THE migration of birds is a subject which has, I believe, occupied and puzzled the observers of nature in all ages of the world, and which is still but very imperfectly understood. Were persons in various parts of the globe—particularly in such situations as are favorable for observation—to note down and make known the results of their individual experience, we might hope more speedily to arrive at the solution of the mystery, by collecting and comparing such scattered records. With this view, I beg leave to lay before the Society the general results of my observation of migrating birds, in the valley of *Nepal*; and, as the grallatorial and natorial tribes would seem to be, at least in the East, the great and steady nomadic class of the feathered creation, I shall, in this paper, confine myself to them.

The valley of *Nepal* in shape resembles an oval or rather a diamond, being about sixteen miles in largest diameter either way; it is situated about half way between the plains of *India* and those of *Tibet*. The distribution of its seasons is essentially tropical; the valley is elevated above the sea about four thousand five hundred feet; and consequently the temperature averages from ten to fifteen degrees of Fahrenheit lower than that of *India* generally. The face of the valley is bare of wood and jungle, nearly every part of it being under cultivation, of which rice forms the principal object; and its population is dense and spread, at all times, for one industrious purpose or other, over almost every field in the country. The streams are numerous, but shallow! permanent swamps are small, but frequent. From the middle of November to the middle of February, little rain falls; the soil becomes gradually and slowly desiccated of its autumnal load of moisture; the cold is too severe for winter crops; and, hardly a blade of grass, or of corn, is then to be seen. From the middle of February to the middle of June, various sorts of mustard, pulse, field vegetables, and wheat, successively occupy a dry soil, which is daily growing drier; the accessions of fresh moisture from the spring showers being very moderate. From July to October the rains prevail, and rice covers the greatest part of the land; which is flooded, to promote its growth, in the earlier months: in the later months, as the successive crops ripen, the water is no longer artificially retained. The rains terminate usually with September: the first crops of rice are cut in the earlier fortnight of that month; and the last crops in the concluding half of October.

These general remarks upon the position, climate, and aspect of the valley will prevent the necessity of reiteration, by showing at once how far the country is fitted for the temporary abode of the birds alluded to: and, with reference to those birds which seek and frequent moist *woods*, it is only necessary to add, that the mountains confining the valley are covered every

where with the noblest garniture of trees and copiously supplied with rills, and with mould saturated by these rills.

The wading and natatorial birds, generally, make a mere stage of the valley, on their way to and from the vast plains of *India* and *Tibet*, the valley being too small, dry, open, and populous for their taste—especially that of the larger ones. Some, however, stay with us for a longer or shorter time, in their vernal and autumnal migrations: and some, again, remain with us throughout that large portion of the year, in which the climate is congenial to their habits. Of all of them, the seasons of arrival, both from the north and from the south, are marked with precision; and I am led to conclude from what I have observed here, that the mass of the grallatores and swimmers are found in the plains of *India*, only during the cold months: for they all arrive in the valley of *Nepal*. from the north, towards and at the close of the rains; and all as regularly re-appear from the south, upon, or soon after the accession of the hot weather. In my enumeration of them, therefore, I shall divide the birds into the three classes, above indicated.

1st.—Of such as usually pass over the valley, seldom alighting, and only for a few hours.

2d.—Of such as alight and stay with us for a few days; or, at most, weeks.

3d.—Of such as seem to seek the valley—not as a caravansary merely, or house of call, for momentary or temporary sojourn in, on their way to some remoter abode—but, as their permanent dwelling place for the entire season.

A 4th class will be constituted of such as do not appear to migrate at all; notwithstanding that all their nearest kindred (so to speak,) do so regularly.

Class I. embraces—

Order NATATOIRES. Family *Anatidæ*; the Genera *Cygnus* and *Anser*: Family *Colymbidæ*, none; Family *Alcadæ*, none. Family *Pelecanidæ*; the Genera *Phalacrocorax* and *Pelecanus*. Family *Laridæ*; the Genera *Sterna*, *Viralva*, and *Larus*.

Order GRALLATOIRES. Family *Gruidæ*; the Genus *Grus*. Family *Ardeidæ*; the Genera *Ardea*, *Phenicopterus*, *Platalea*, *Ciconia*, *Mycateria*, *Anastomus*, *Tantalus*. Family *Scolopacidæ*, none. Family *Rallidæ* the Genus *Glareota*. Family *Charadriadæ*; the Genera *Himantopus* and *Edicnemus*.

Class II. embraces—

Order NATATOIRES. Family *Anatidæ*; the following Genera, *Tadorna*, *Anas*, *Hynchaspsis*, *Dafila*, *Mareca*, *Querquedula*, *Merganser*, *Truligula*. Family *Colymbidæ*, none. Family *Alcadæ*, none. Family *Pelecanidæ*; the Genera *Phalacrocorax* and *Pelecanus*.

Order GRALLATOIRES. Family *Gruidæ*; the Genus *Anthropoides*. Family *Ardeidæ*, the Genus *Ibis*. Family *Scolopacidæ*; the Genera *Numerius*, *Limicula*, *Recurvirostra*, *Limosa*, *Rhynchœra*, *Pelinda*, *Phæopus*. Family *Rallidæ*; the Genera *Rallus*, *Parra*, *Gallinula*, *Porphyrio*, *Fulica*. Family *Charadriadæ*; the Genera *Erolia*, *Squatarola*, *Vanellus*, *Charadrius*.

Class III. embraces—

Order NATATOIRES. Family *Anatidæ*; the Genera *Mareca* and *Querquedula*, (where *protected*, as in some sacred Tanks). Family *Colymbidæ*, none. Family *Alcadæ*, none. Family *Pelecanidæ*, none.

Order GRALLATORES. Family *Gruidæ*, none. Family *Ardeidæ*, the Genera *Botaurus*, *Ardea*, *Ciconia*, Family *Scolopacidæ*, the Genera *Gallinago* and *Scolopax*. Family *Rallidæ*; the Genera *Parra*, *Rallus*, and *Fulica*, (where protected, in holy Tanks). Family *Charadriadæ*; the Genus *Charadrius*, (one small species of.)

Class IV. embraces—

Order NATATORES, none.

Order GRALLATORES. Family *Gruidæ*, none. Family *Ardeidæ*; the Genera *Ardea*, (small species, or *Baklas*, only) and *Nycticorax*. Family *Scolopacidæ*; the Genera *Totanus*? and *Gallinago*? Family *Rallidæ*; the Genus *Rallus*. Family *Charadriadæ*—the Genus *Vanellus*, one species—the *Tithiri*.

N. B.—The notes of interrogation merely denote a doubt whether the Genera so indicated belong to Class III or IV.

REMARKS UPON THE ABOVE ENUMERATION.

The Grallatorial and Natatorial birds begin to arrive, from the *North*, towards the close of August, and continue arriving till the middle of September. The first to appear are the common snipe, and jack snipe, and *Rhynchæa*; next, the Scolopaceous waders (except the woodcock;) next, the great birds of the heron and stork, and crane families; then, the Natatores; and lastly, the woodcocks, which do not reach us till November. The time of the re-appearance of these birds, from the *South*, is the beginning of March; and they go on arriving, till the middle of May. The first which thus return to us are the snipes; then come the teal and ducks; then the large Natatores; and lastly, the great

cranes and storks. It will be noticed that the Grallatores which visit us, or pass over us, are much more numerous than the Natatores ; and, unless I am mistaken, observation in the plains of India would satisfactorily prove that this is a just and decisive indication of the superior prevalence of wading over swimming birds in that extensive region. India, I fancy, is too hot for the taste of the Natatores—a great majority of which seem to affect arctic regions, or, at least, high latitudes : I throw out the remark for canvass and enquiry : and, for fear I should deceive any one by the display of the Genus ‘*Cygnus*’ at the head of my list, I must add that the wild swan was never seen here but once, in the mid winter of 1823, when the apparition suggested a new version of the well known hexameter—

‘*Rara avis in terris, alboque simillima cygno.*’

Such a bird is never seen, I suppose, in the plains of India?

None of the Natatores stay with us, beyond a week or two, in autumn, (when the rice fields tempt them) or beyond a few days, in spring ; *except* the teal, the widgeon, and the coot, which remain for the whole season, upon some few tanks whose sanctity precludes all molestation of them. There are cormorants throughout the season upon the larger rivers within the mountains ; but none ever halt in the valley, beyond a day or two : for *so long*, however, both they and pelicans may be seen, occasionally, on the tanks just mentioned.

Lest any one should admire my enumeration of *Larus*, and *Sterna*—birds which usually affect the high seas—I think it proper expressly to say that I have killed both the red-legged Gull, and a genuinely pelagic Tern, in the valley ! But, so have I *fishing* Eagles ; and, in truth, who shall limit the wanderings of these long-winged birds of the *Ethereal* expanse ?

It will be observed, that I have not followed the arrangement of Cuvier, but that of Stevens, apud Shaw. The latter is adopted from our distinguished English Zoologist, Vigors; and as I think his distribution of Birds possesses many advantages, I have given it the preference to that of Cuvier, how much soever I may reverence the genius and knowledge of this distinguished Naturalist. Perhaps it may be objected to my enumeration that it ought to have descended to *species*; to which I answer that, besides the prolixity of such a catalogue, the avowed principle of the distribution of the feathered tribes which I have followed, is, to separate into a distinct genus, every bird or small group of birds which is distinguished by any marked peculiarity of organization or manners, whence it is probable, that my generic enumeration will suffice for every useful purpose.

NIPAL RESIDENCY, }
5th October, 1831. }

VIII.

THE WILD GOAT, AND THE WILD SHEEP, OF NEPAL.

BY B. H. HODGSON, Esq.

ACTING RESIDENT AT KATHMANDU.

I.—THE JHÁRAL WILD GOAT, *Capra Jháral*. (Mihi.)

Habitat, juxta-Himalayan Mountains of Nepal.

SPECIFIC CHARACTER.

GOAT with short, thick, simply recurved, sub-triangular, sub-compressed, carinated horns ; sharp above, flat beneath ; towards the tips, smooth and rounded : with beardless chin and double coat.

This capricious, vigorous, and agile, yet tractable and intelligent, animal, measures from the tip of the nose to the root of the tail, four and a half feet nearly ; and stands two and a half feet high, at the shoulder.

His peculiar habitat is confined to the regions in the vicinity of the snows—but I am not aware that he ever ventures amongst the actual glaciers. He is capable of enduring, perfectly well, the heat of the valley

of *Nepal*; and can be tamed and brought up in confinement, there, with the greatest facility. He possesses entirely the characteristic manners of the genus, so finely delineated by BUFFON. Soon after his capture, (if he be taken young,) he becomes content and cheerful; and, within a year, he may be safely let out, to graze and herd with the tame sheep and goats. Intelligent and observant, he gives the keeper little trouble; and is an annoyance to the flock, only by reason of his wantonness: but, ever and anon, as it were in sheer contempt of sobriety, he will display the most amazing feats of activity, and the most fantastic freaks of humour. He is very wanton; and so ardently courts the tame females he may be turned amongst, that it is often necessary to deprive him of the tips of his horns, lest he gore them to death; or else to segregate and confine him. I have known him to have had sexual commerce with sheep, goats, and even musk deer; but never, to have begotten young by any of them. From the tame goat he is eminently distinguished by the superior compactness of his frame, length of his limbs, and expressiveness of his head; as well as by his fine deer-like ears and tail.

The body is shortish, full, and compact: the limbs, long but stout: the head moderate, with great vertical dimensions; small fine muzzle, and slightly convexed forehead, running in one uniform plane from the setting on of the horns to the termination of the nasal bones: neck, longish and slender, bowed out and down: ears, small and finely formed, erect, very moderately opened, having short hair outside, and naked almost, within: tail short, depressed; base broad, rapidly pointed: muzzle dry: no lachrymary sinuses. The *Jháral*, in his ordinary quiescent attitude, has the back slightly arched; the withers lower than the croup: the hind quarters very slightly stooped; and the neck, in a small degree bowed, after the fashion of deer and antelopes. There is not a vestige of beard on his chin; the entire lower part of the head

being as closely shorn as the upper surface. Upon the neck, especially the superior surface of it,—and upon the top of the shoulders, the hair is considerably elongated, and has, when the animal is in fine condition, a length of seven or eight inches. The rest of the coat is only of moderate length; and is full, fine, loosely applied to the body, straight, and mixed with a small portion of very fine wool at its base.

The long hair of the neck and shoulders is wavy, straight, and parted on the ridge, or apex of the body. The general colour is slaty gray, mixed with rusty on the flanks: forehead, and top of neck and back, red brown or dusky brown: fronts of the limbs, below the hocks and knees, the same: a line from the eye to the gape, and a lateral patch on the lower lip, the same: tips of tail and ears, black: base of tail, buttocks behind, and round the eyes, clear rusty: inferior surface of the head, impure yellowish: neck below, and centre of the belly, and insides of limbs, the same; but smeared with slaty: irides, brown red: muzzle, hoofs and horns, dusky black.

As it is by the horns chiefly that we are enabled to separate the species of this genus, I shall add a few more words upon them to the careful enumeration of diagnostics in the specific character. The *Jhāra's* horns ascend very little above the crown of the forehead, being directed backwards with a strong convex curve which accurately describes a small segment of a circle; in as much as there is no peculiar twist towards the extremities of the horns. At the base they are in contact; and the separation of the tips is rather created by gradual attenuation than by divergency. Directly *above*, the horns present a sharp edge; which, towards their bases, is strongly carinated; but plain, forwards; and *below*, a broad surface, forming the third side of the triangle, the other two sides of which are the *lateral* surfaces of the horns.

But there is a slight convexity, as well on the inferior, as on the lateral surfaces; and the angles below are somewhat rounded off. Hence, I have characterised the horns, not as triangular, but only sub-triangular; and, as the lateral compression, though distinct, is trivial, I have added that the horns are sub-compressed also. The wrinkles or grooves towards the base are (as usual) transverse, irregular, close, and small. So far as they extend, they go perfectly round the horns, keels and all, in an uniform manner, without any knobs.

The dimensions of the animal are as follows :

	<i>Ft.</i>	<i>In.</i>
Tip of nose to root of tail,	4	4
Length of the head,	0	11
Utmost vertical measure of ditto,	0	7
Length of tail, hair,	0	7
Ditto ditto, flesh only,	0	3½
Height, at shoulder,	2	6
Depth of chest,	1	1
Height of fore-leg, } To line of belly,	{	1 5
Ditto of hind ditto, }		1 8
Length of ears,	0	4½
Ditto of horns, straight,	0	7
Basal height of horns,	0	3½
Ditto breadth of ditto,	0	1½
Weight 80 lbs.*		

* Among the papers communicated to the Society by the late Mr. DUVAUCEL, is a description of a Wild Goat of Nepal, which in some measure corresponds with the above, although for want of a plate, it is impossible to remove all doubt on the subject. As that distinguished naturalist's discoveries were uniformly transmitted to Paris for publication, the Asiatic Society deemed it superfluous to give insertion to his papers in their *Recherches*, but now that a separate volume is set apart for Physical subjects, the same reason does not apply, and all that can elucidate the natural history of India obviously falls within the scope of the present branch of their *Proceedings*:—the French description is therefore here inserted from the Author's original Manuscript.—*Sec.*

“ *Notice sur une Chèvre Sauvage, des montagnes du Napaul.*

“ Les chèvres sont de tous les mammifères ceux dont la tradition est la plus incertaine et la zoologie doit saisir avec empressement tout ce qui peut l'éclairer dans cette partie si confuse et si intéressante de son histoire.

To the above account of a wild Goat, proper to *Nepal*, I may as well add a short notice of wild Sheep of the same region; although I am acquainted only with the female of the species. This animal dwells north of the *Jhàral*, immediately beneath and amid the permanent snows, and is named, by the *Nipalese*, *Nayaur*, or *Nyaur*. It is distinguished by them (and, I fancy, justly) from the *Ovis Ammon* or *Argali*; which latter

Un examen sévère de leur nombreuse nomenclature, en indiquant la chèvre sauvage de Perse, (*capra agagrus*, Gmel.) comme la source de toutes les chèvres domestiques, a également admis, pour espèces primitives, le Bouquetin du Caucase (*capra Caucasica*, Guldens.) le Bouquetin de tout l'ancien continent (*capra ibex*, Lin.) et le Bouquetin à crinière d'Afrique (Daniels *Afric scenery*, 81. XXIV.) aux quels nous ajouterons la chèvre de Sumatra, (*cumbing-oulang* de Marsden,) si distincte de toutes les autres par une grosse protubérance sphérique située au dessous des yeux.

Avant d'être modifiés par la domesticité, les caractères génériques de ces animaux consistent principalement dans la disposition de leurs cornes dirigées en haut et en arrière, et dans la présence d'une barbe au dessous de la mâchoire inférieure. Quand aux caractères spécifiques, ils sont déterminés par la forme même des cornes, de sorte que l'on peut admettre comme espèce primitive et nouvelle, toute chèvre sauvage qui présentera, sous ce rapport, des différences constantes et notables.

Les espèces indiquées ci-dessus sont si bien connues, qu'il n'est pas besoin de rappeler leur description pour rendre sensible ce qui les distingue de la chèvre rapportée récemment du *Napaul* par M. WALLICH, nous bornant donc à décrire celle-ci avec exactitude, on saisira facilement les dissemblances qui la désignent comme une espèce nouvelle ou peu connue.

Sa taille est à peu près celle d'un bouc domestique, c'est-à dire qu'elle a environ 2 pieds 10 pouces à la partie la plus élevée du dos. Ses cornes sont cylindriques, annelées irrégulièrement à leur base, arquées dans toute leur longueur et dirigées en arrière vers le haut; les oreilles sont droites et la queue toujours basse; au dessous de l'angle interne des yeux est un vestige de larmier; le menton est privé de barbe et derrière chaque oreille se trouve une glande recouverte par la peau et qui sécrète une matière inodore s'écoulant par un petit trou percé au milieu.

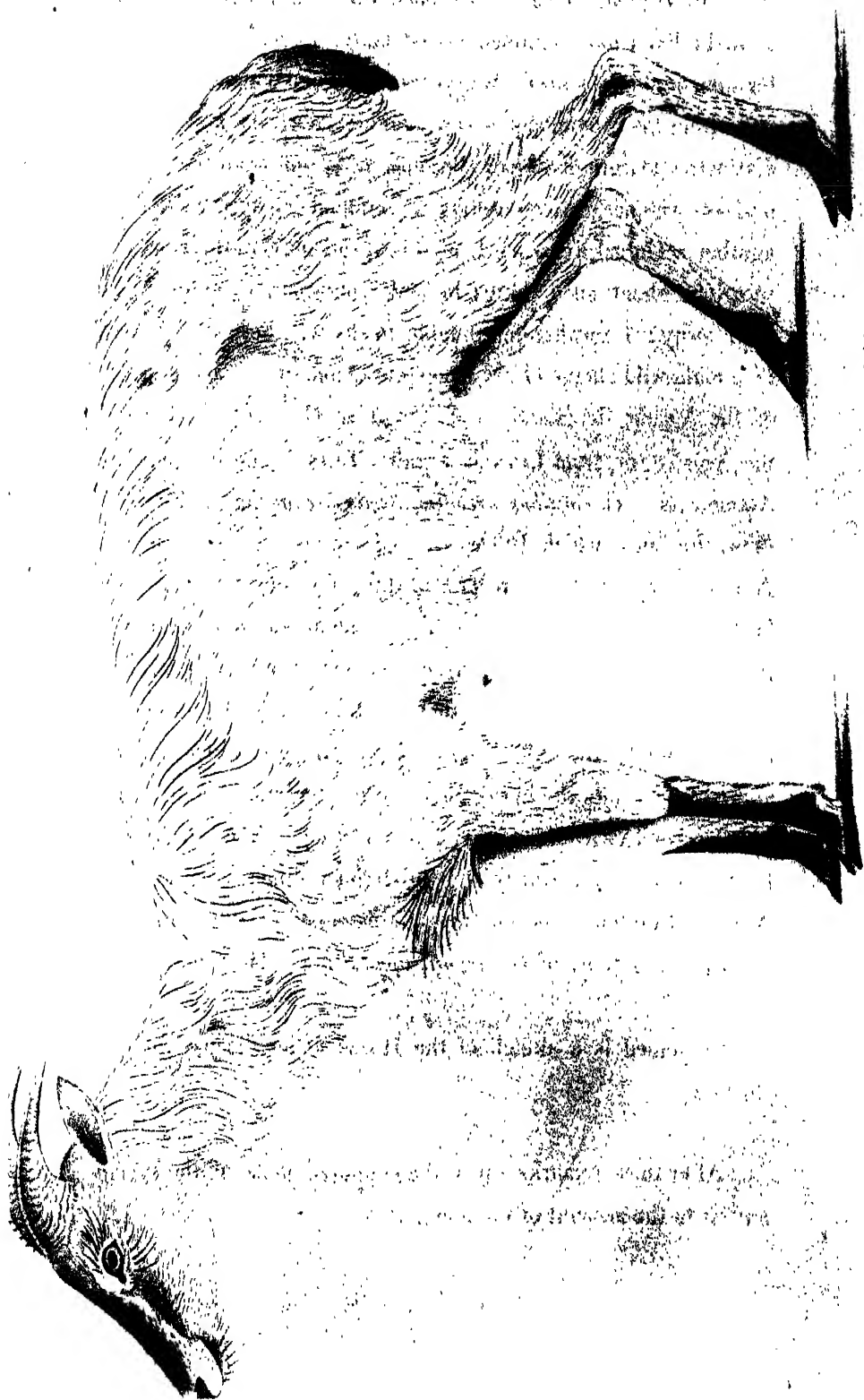
Le pelage de ce Bouquetin se compose de deux sortes de poils, ainsi que celui de toutes les chèvres et de beaucoup d'autres animaux. Le plus long est pendant, rude et grossier, l'autre un peu frisé, soyeux et rare. Ce pelage est d'un gris varié du fauve et de noir; le fauve domine au ventre et sur les membres; le noir s'étend sur les parties supérieures et trace même une raie distincte de l'occiput à la queue. La gorge d'un beau blanc se dessine nettement sur le fauve du cou.

L'individu que nous décrivons est un mâle qui paraît jeune encore. Son corps élancé, ses mouvements brusques et ses jambes de derrière plus hautes que celles de devant sont les conditions d'une parfaite agilité commune à tous les animaux de ce genre. Il a été rapporté des frontières du *Napaul* par M. WALLICH et se trouve également dans les montagnes de l'est limitrophes du *Bengale*."

they call *Bharal*. I have never been able to procure the *Bharal*, alive or stuffed : but I have obtained, occasionally, his horns, so justly celebrated for their prodigious size. Six years ago, I had a pair which I could only raise from the ground by a considerable effort. I mention this strong distinctive feature of Argali, because it is one that is familiar to the natives; who are thence unlikely to confound the species, so marked, with another. Unluckily, when I possessed the horns of the *Bharal*, I was too incurious about such things to make any note upon them, ere I gave them away : I am therefore unable to say whether the dry, stuffed, head of a male wild sheep which I now have, and which professes to be that of the *Nayaur*, be essentially different in character from the *Bharal* of the *Nipalese*, or, from LINNÉ'S Argali. LINNÉ'S specific character of *Ovis Ammon* is "*O. cornibus arcuatis, semi circularibus, subtus planiusculis.*" Now, the horns which I possess, and suppose to be those of the male *Nayaur*, are directly the reverse of this; for they present a sharp angle below, and a broad flat surface above; being in shape accurately triangular; with two sides of the triangle constituting the lateral surfaces of the horns, and the third side, their frontal or superior, surface. Beneath, there is merely the acute angle of the triangle. Besides, though the animal which bore the horns in question died ere he had quite completed his second year, his horns, large as they are, could never, I think, have reached, at maturity, the prodigious dimensions of those of the Argali. In other respects, these horns answer sufficiently well to the description of those of *O. Argali*, *apud* Shaw.—II. 379-80.

Subjoined is a sketch of the Horns under discussion, attached to the skull.

After these remarks upon the supposed male of the species, I now hasten to the account of the female.



The JHARAL, or Wild Goat of Nepal. (Capra ibex, and ibex, Himalayas.)

II.—THE NAYAUR WILD SHEEP.—*Ovis Nayaaur*. (Mihi.)*Habitat*. The Himálaya.

SPECIFIC CHARACTER.

The male? with large, accurately triangular, horns, flat above and cultrated beneath; curved and wrinkled as in the common ram:* a double coat: and beardless chin and neck. The female, with small, strongly*depressed, sub-erect, sub-recurved, and divergent, horns, obsoletely wrinkled.

In proceeding from the description of an individual of the genus CAPRA to that of one belonging to the genus Ovis, it is scarcely possible not to pause and pay a tribute to the elegant genius of BUFFON. Deficient, perhaps, in scientific precision, he yet studied nature with a truly philosophic spirit; and his pictures of the *manners* of animals are no less useful than delightful.

Nature having separated the sheep from the goat by no palpable *physical* signs, we consult LINNÉ in vain for directions under which genus to place a newly discovered species of either; but, if we can procure living individuals of the species, and so observe their demeanour, we have but to turn to BUFFON's lively and just contrast of the manners of the two genera, to be satisfied as to whether our animal be goat or sheep.

* LINNÉ's specific character of Argali gives horns, "arcuated, semicircular and flattish beneath"—that of *Ovis Aries*, "horns, compressed and lunated." Now, *Ovis Aries* is the common Ram: yet, SHAW says the horns of Argali are curved and shaped like those of the common Ram! I do not understand all this; but may as well add, ere I conclude this note, that my supposed male *Nayaaur* has his horns curved, and formed generally like the common Ram's horns, from which they differ chiefly by being more accurately triangular. Are Argall's horns *trilateral*?

Though I have kept and petted the *Jháral* and the *Nayaur* for years, I could never, with the dry Linnean aid of SHAW, have affirmed that the former was a goat, and the latter a sheep, but for the *moral* characteristics of the genera furnished me by the graphic BUFFON! I have mentioned that the *Jháral* is a saucy, confident, capricious, clambering animal, whose freaks of humour and of agility are equally surprising. The *Nayaur*, on the contrary, is a staid, simple, helpless thing, which never dreams of transgressing the sobriety of a sheep's nature. Like the *Jháral*, it is easily tamed, but requires more care to acclimatise it in the valley. I have tried in vain to breed from the *Nayaur*. Comparing the figure and general aspect of the two animals, it can merely be noted, in the way of distinction, that the *Jháral* is the more compactly framed, and stands straighter and firmer on his legs, than the *Nayaur*; and that the former has an arch genuinely goatish expression of the face—the latter, the proverbially simple look of the sheep.


As compared with the tame sheep, it is very obvious to remark that the *Nayaur* has a fuller, shorter body; much longer limbs; a longer neck; and ears and tail of a more deer-like character.

In the ordinary state of rest the *Nayaur*, instead of the straight back, neck, and limbs of the tame sheep, has the arched back, bowed neck and stooping hind quarters of the feet, and graceful antelopine and cervine races. There is a *great* drop from the shoulders; and the withers are lower than the croup: the head, as in the *Jháral*, but rather more rectilinearly tapered from above and below: ears, tail, and hoofs, likewise, as in the *Jháral*; but the hoofs longer and less compact, and the ears larger.

The coat or covering of the *Nayaur*, as nearly as possible, resembles that of the *Chirú* or *Antelope Hodgsonii*; the most careful comparison only enabling one to say that the latter, from being somewhat thicker,

is more perfectly porrect from the skin ; and that each of its hairs waved beneath the surface,* whereas the hair of the *Nayaur's* hide is straight—not merely in its general direction, but, in all its length, from point to point, of each hair.

Excepting such minute variations as these, all the ruminantia of the *Himálaya* and *Tibet*, which I have seen, are similarly clothed. There is always an outer coat and an inner : the latter, spare, very fine, woolly, more or less applied to the skin : the former, very thick, porrect, and of a substance which we must call hair, though it resembles not ordinary human or animal hair, or bristles. It is stiffish, brittle, feeble, rather thick or coarse, and of a quill-like feel and look. It might be imagined that this sort of hair is peculiarly adapted for protecting its wearers from cold : but dissection and the microscope fail to detect any peculiarity of structure.†

* It is not a twist, or, spiral convolution, but an alternation merely, on the sides, of salient and resilient curves. 

† I speak under correction, and am favored by Dr. BRAMLEY with the following observations :

“ It is most difficult to dissect a hair ; but so far as I have performed the operation, the result confirms Mr. HODGSON's observation.

In regard to the waviness of the *Chiru's* hair, having examined a section of the fleece, and having found the alternations of salient and resilient curve locking into each other (that is, the salient bows of one hair fitting into the resilient bends of another) it struck me that this peculiar conformation might be of more importance than Mr. HODGSON seemed to imagine. I thought so when I examined the hair, and retain the opinion on reflection ; as matter of conjecture merely, I would state, that the waviness of the *Chiru's* hair—which is more distinctly marked from the base upwards—may serve the specific purpose of confining the wool beneath in closer adaptation to the skin, under all changes of attitude by the animal, than if the hair were straight, and may thus constitute an additional security against injury from the rigour of that region which forms the *Chiru's* habitat.”

J. M. BRAMLEY.

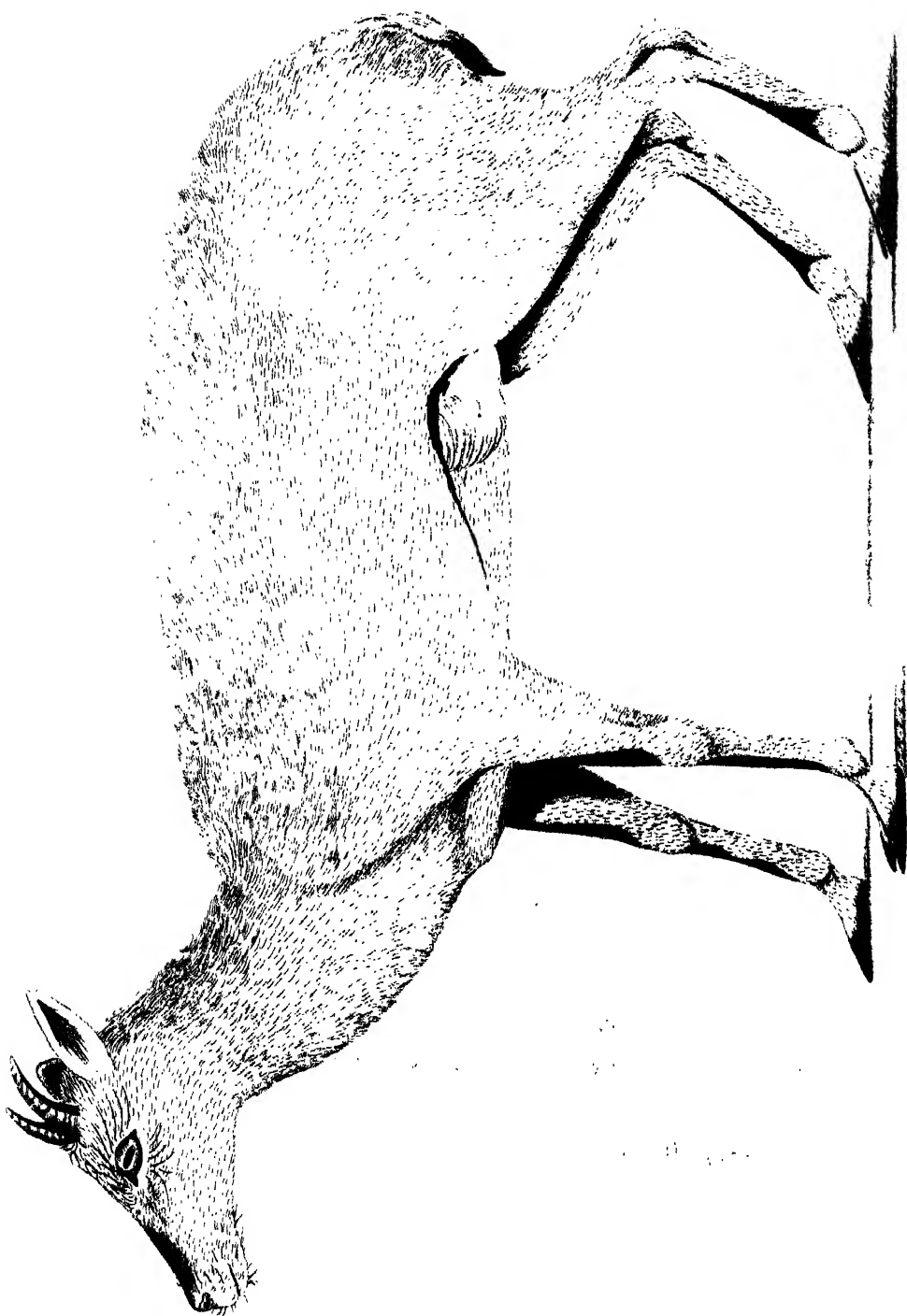
The general and pervading colour of the *Nayaur* is a pale, dull, brownish, slaty-blue, which, however, merges into more superficial tints,— of rufous, on the flanks, hams, and shoulders; and of yellowish white, upon the cheeks, lips, abdominal surface of neck, belly, and insides of limbs, of ears, and of tail: bridge of nose, fronts of limbs, tips of ears and of tail, patch on chest, and line separating flanks and abdomen, dusky brown: in old animals, vertical line of neck and body, the same: iris, speckled, brown-red: muzzle, black: hoofs and horns, dusky.

Dimensions (of female) as follows :

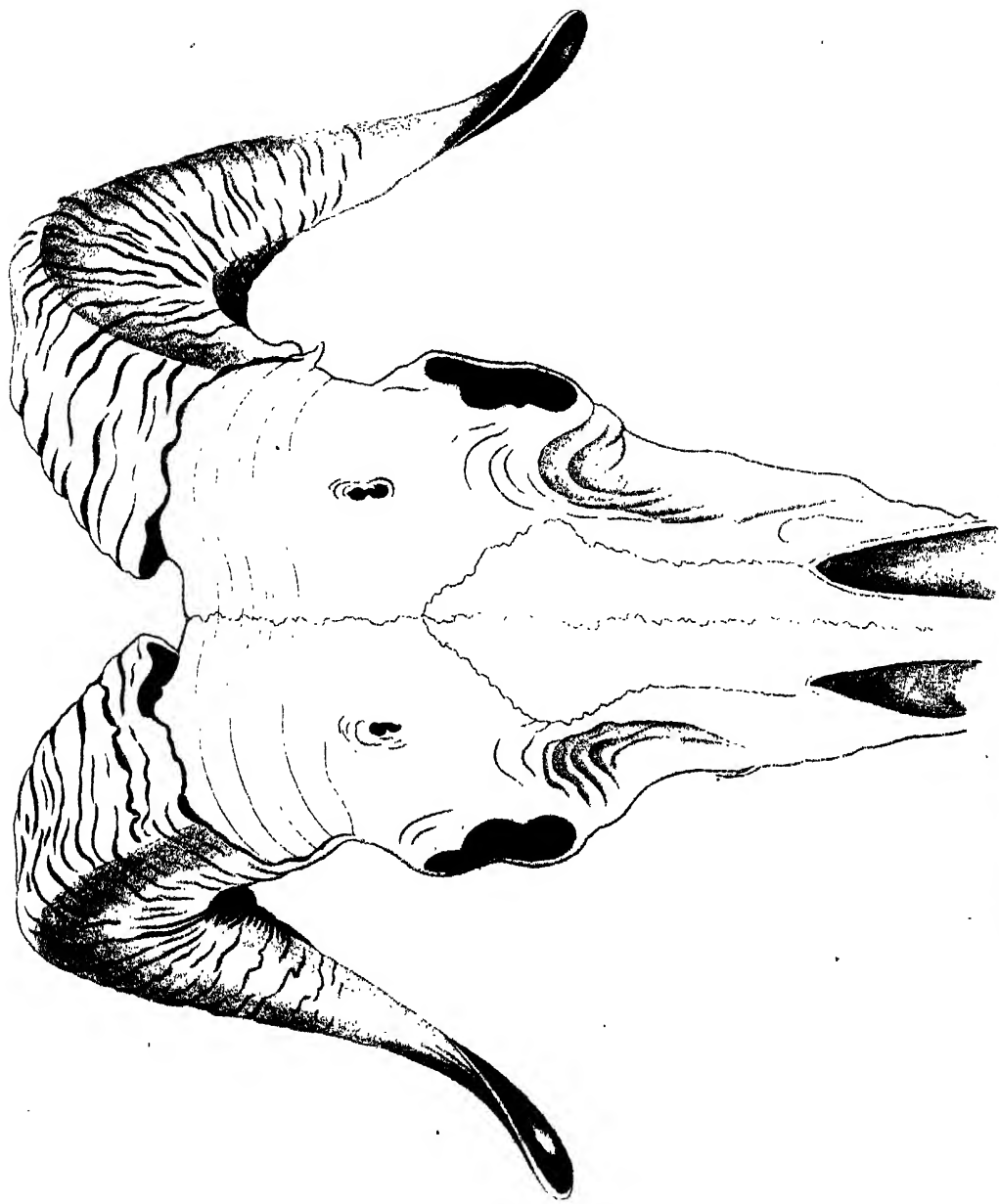
	Ft. In.	
Tip of nose to roots of tail,	3	4
Length of the head,	0	9½
Ditto of tail to end of hair,	0	7
Height of animal, at the shoulder,	2	4½
Depth of the head,	0	6
Ditto of the chest,	1	0
Length of fore leg to line of belly,	1	5½
Ditto hind leg to ditto,	1	8½
Ditto of the horns, straight,	0	4
Basal breadth (across,)	0	1½
Ditto height, (fore and aft,)	0	0½
Ditto interval,	0	0½
Length of the ears,	0	5½
Weight (of a very thin animal) 75 lbs.		

N. B. The dimensions are taken from a female of less than four years old, three of which she had passed in confinement.

NEPAL, October 5, 1831.



THE NYAUR or Wild Sheep of Nepal. (His Nyaure from Himalayan.)



HORNS and SKULL of the WILD SHEEP of the Himalaya.
male, 20 months old - Orvis Naysur or Arvali.

IX.

ON THE

RATWA DEER OF NEPAL.

By B. H. HODGSON, Esq.

ACTING RESIDENT AT KATHMANDU.

III. THE RATWA DEER.—*Cervus Ratwa* (Mihi)

CERVUS MUNTJAC ?—Pennant.

Habitat. Central and lower Hills of Nepal, and great Saul forest.

SPECIFIC CHARACTER.

Small red Deer, with very small, suberect, sublunated, bi or trifurcate, rounded, horns, set on lofty, hairy, compressed, pedestals; and with frontal as well as suborbital fissures.

This remarkable animal, whose horns bear some remote analogy to those of *Camelopardulis*, which is affined to *Moschus* by its tusks, and to *Capra* by its shortish and full body, as well as by its capricious and airy manners, has yet all the influential characters of *Cervus*, to which Genus it unquestionably belongs its muzzle being very moist, its suborbital sinuses extremely conspicuous, and its horns, annual, bony, and branched. But these horns, instead of being amply developed and springing immediately from the crown of the forehead, after the manner of most, if not

of all, others, of the Cervine Genus, are so small as to deserve almost to be termed obsolete; and are elevated on pedestals higher than themselves, which pedestals are, nevertheless, covered to their summits by a continuation of the skin of the forehead. So that when the *Ratwa* periodically sheds his real horns, their pedestals, as above described, remaining, give the animal's head the very appearance of that of the *Giraffe*, so far at least, as the frontal prominences are concerned. Nor is this all: for, as much as these pedestals of the horns ascend above the crown of the forehead, so much do they descend below; their origin being the very extreme points of the *os frontis*, considerably below the insertion of the nasal bones. Here, then, the pedestals of the horns commence; and, in the shape of two prominent ridges, gradually diverging, they run along the outsides of the entire length of the forehead, only quitting the skull at the outer angles of the sutures connecting the frontal and parietal bones. Yet more: down the inner side of either of these ridges of the pedestals runs a most singular fissure, formed by a strong reflexion of the skin. The margins of the fissures are full and dilatable; and the animal expands them under excitement as well as applies them, so expanded, to objects of curiosity with the apparent purpose of feeling or smelling such objects; just as he applies the suborbital fissures. The frontal fissures are about two inches long, straight, and longitudinally directed down the sides of the *os frontis*. The skin is continued without interruption or sensible diminution of thickness throughout their interior: but the interior is nearly denuded of hair. When the hide is stripped from the carcase, there is no internal indication, not even the crease,—of the strong folds prevailing on the outside of the skin and forming the fissures: but there is a very slight indentation of skull corresponding with them.

The ridges of the pedestals are elevated nearly one-third of an inch, above the sides of the *os frontis*; and their substance is solid, and bony, like that of the skull, of which indeed the ridges form an integral part,

without the intervention of any suture. From the point where these ridges commence, to that at which they rise above the crown of the skull, their length is about four inches. From the latter point, the pedestals proceed, rectilinearly, but inclined rather backwards, about three and a half inches more; and there they terminate, and the horns commence. In this second portion, the pedestals are bony as before, and entirely covered, by a continuation of the frontal skin, with rather more than its usual quantity of hair on them. The pedestals have, in this their fully developed part, a strong lateral compression; their shape being precisely that of an ordinary stick of sealing wax; and uniform throughout. They have a gradual and not inconsiderable divergency amounting to about three inches at their summits. At the crown of the skull, their interval is about two inches. The horns which rise from these remarkable columns have all the well known characters of the genus. They fall off and are renewed, annually, between June and September; their nucleus being a swollen marginal protuberance, just like the burr of the horns in common Deer. The horns are very insignificant, having an extreme length of about three and a quarter inches, and only a proportionate thickness. Like that of the pedestals, the general direction of the horns is upwards, with an inclination backwards. They are rounded, in the main, but have a slight lateral compression near to the pedestals: their surface, in general, smooth, but furrowed, more or less, by longitudinal grooves. The principal curve of the horns is an outward or lateral convexity, with the points turned, very decidedly, inwards; and, less decidedly, backwards, but not absolutely "hooked"—at least not in the majority of individuals. Hence, in the specific character, I have called the horns *sublunated*. But the term can only be justly used in a qualified sense; and, as not merely the points but the upper halves of the horns are, in some specimens, convexly turned *back*, though, in a less degree, than they are bowed laterally, perhaps they might be little less justly characterised as *subrecurved* than as *sublunated*. From the base of either horn proceed one or two erect,

short, conical, branches—sometimes one from the one horn, and two, from the other of the same pair of horns. These branches (so to speak) are never above an inch long—where there is one only, it is thick—where two, they are slender. The second branch or antler is so rarely met with that it ought perhaps to be considered a *lusus* merely, and as such should be excluded from the specific character of this species : but, as I have one fine specimen in which two basal antlers are developed, and, as PENNANT expressly says his Muntjac is trifurcately horned, I think it safest to designate the *Ratwa* as bi-or-trifurcate, and not as positively bi-furcate only.

HAVING thus painfully, and I fear, tediously, described the pedestals, horns and frontal fissures, of the *Ratwa*, I shall now proceed to the account of its manners, haunts, appearance, size, and remaining characters.

This elegant and lively little animal bears a great resemblance in size, figure, and carriage to the Porcine Deer of the plains of India : but the *Ratwa* is the lighter and more graceful, considerably, of the two. His motions are full of elegance and elasticity, and he stands and even walks upon his toes rather than upon his entire hoofs, as though he disdained to touch the ground. In a quiescent state his back is much arched ; his hind limbs stooped ; his withers lower than his croup ; his neck retracted, and bowed downwards and outwards ; his head carried low ; and his tail closely applied to his buttocks. Excite him ; and he will, at once, straighten his back, raise his fore quarters and head, erect his scut, and appear instinct throughout his frame with spirit and agility ! I have seen him, in pure display, as it were, separate his fore and hind legs extremely, and throw his back into a concavity as decided as ever is the convexity of the attitude of rest. The body of the *Ratwa* is, for a Deer, short and full : the limbs, too, short ; and stout as far as the hocks and knees—below them, exceedingly slight and fine : the hoofs, small and compressed : the false hoofs inconsiderable in size and blunt : the tail, longish, tapered, cylin-

drico-depressed, moderately and uniformly clothed with hair; in general resembling the tails of the Axis and Fallow Deer: the neck, shortish and rather spare: the head, rather large; of small vertical dimensions; tapered; the nose acuminated, and having a well defined, moist, and naked muzzle: the eyes large and beautiful, with transverse oblate pupils: the ears, rather small and well formed; moderately opened; the lining, a small quantity of longish, soft, hair, disposed into stripes or striæ on a naked ground; the tips, rounded. I have already observed that the muzzle is moist; and the suborbital sinuses, large and conspicuous. Comparing the cranium of the *Ratwa* with the skulls of other and large Deer, nothing markedly peculiar to the former arrests the attention save the two elevated ridges bounding the whole extent of the frontal bones, and which have been already particularly noticed. The cranium of the *Ratwa* may, however, be further distinguished by the relative length of the frontal, and correlative shortness of the nasal bones. The *Ratwa's* forehead is decidedly, tho' slightly, convex; and the usual drop or depression is further forward, and less sudden than it is observed to be in large Deer. Owing to the character and position of their respective horns, the brain is thrown less far back; and, lastly, the nasal bones are void of that arcuation which usually belongs to those of large Deer. The bony cavities prepared for the lachrymal sacks, and corresponding with the suborbital fissures of the superficies, are, in the *Ratwa*, as large as, or larger even in proportion, than, those of the huge *Bára Sinha's* head. The tusks of the *Ratwa* have the same general character with those of the proper or *Tibetan Musk*:* but they are shorter, stouter, less compressed, and much more curved. The portion exerted from the jaw is about $1\frac{1}{4}$ inch in length,—measured straightly— $2\frac{1}{8}$ inches in extent as measured along the curve. They are loose in the sockets, but fixable at the animal's pleasure. The *Ratwa*, when taken young, can be tamed as easily and effectually

* Vide Shaw's General Zoology, vol. II. p. 250.

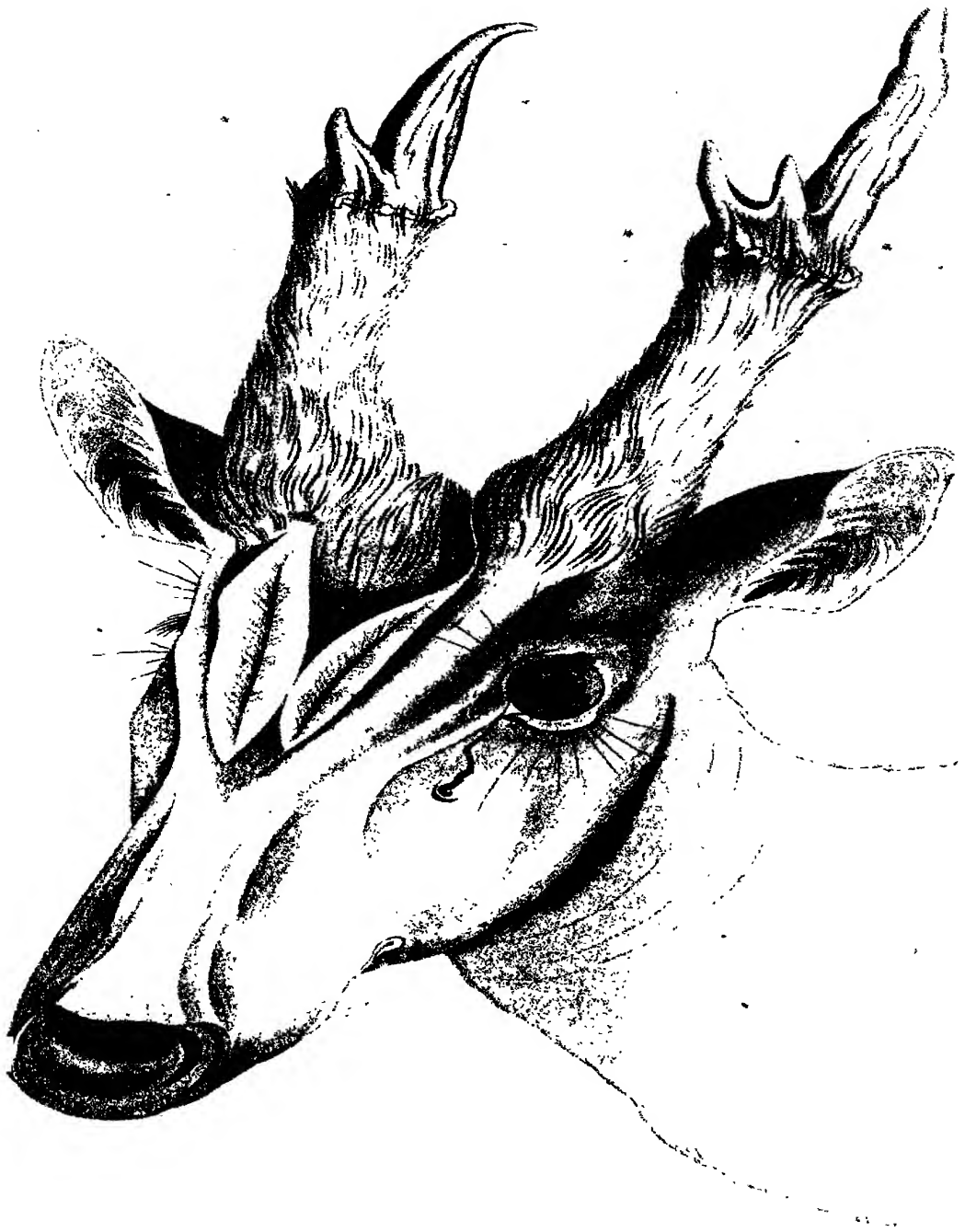
as the spotted Axis: but it is volatile and capricious in its temper, reminding one a good deal of BUFFON's exquisite description of the Goat: only the *Ratwa* loves not rocks and precipices; nor possesses the Goat's wonderful power and propensity to climb and spring. The tamed *Ratwa* is a confident, fearless, creature, which, small as it is, will not retreat before man or dog, annoying it; but will (the male) turn on the assailant and attack resolutely both with its horns and tusks—cutting with the latter, in the manner of the wild Ilog. The female of the species is gentle and timid, having neither horns or tusks; but, in place of the former, two bristly patches of dark hair like eyebrows—and of the latter, small conical canines not protruding from the mouth. She has four teats, disposed quadrangulary on a white udder; and a specimen procured on the 28th February, had the udder teeming with milk. This individual must have just dropped her young. She is rather smaller and paler in colours than the male. The *Ratwa* is about three feet five inches long, exclusive of the tail; about one foot eight inches in height, at the shoulder; and from forty to fifty lbs. in weight. Colour, a bright, uniform, full, yellow red;—darkest, above; palest, below, or on the belly and pectoral surface of the neck: forehead and limbs obscured with dusky-brown: insides of thighs, a patch on either side the chest, insides of ears and tail, pure white: a blotch of black in front of each pedestal of the horns, where the pedestals quit the forehead, on the inferior surface, and a good deal of the upper lip, impure white: irides, dark brown; muzzle and hoofs, black: coat or hair, close, full, soft, short, applied to the skin; in the living animal always exquisitely clean and void of all offensive odour.

The *Ratwa* is found in the great central mountains of *Nipal*, as well as in the small hills beneath them, and in the great forest at their foot. He is more common, however, in the latter than in the former tracts; and in the former he confines himself to the basal and gently sloping parts of the mountains; and, of them, to such

districts only as are closely screened by brushwood, in the midst of which the *Ratwa* always has his lair. The species is gregarious—the herds usually amounting to from twenty to thirty individuals. The mountaineers denominate the animal, *Ratwa*. It is not known to the plains of India, I believe ; nor to any other of the Indian mountains, as far as I am aware. Whoever will turn to SHAW's General Zoology, vol. II. p. 301, will find there the description of a small species of Deer denominated the Rib-faced Deer, or *Cervus Muntjac*, belonging to Java and the Malayan Peninsula ; which I apprehend to be either a variety of the *Ratwa*, or another species most closely allied to ours. But SHAW's description is so wretchedly imperfect that it is impossible to speak with any confidence about it. I recommend the curious in such matters to read attentively my description and then to refer to SHAW's ; by which means they will be able to appreciate the following remarks. The specific character of *Cervus Muntjac* gives “ cylindric ” pedestals to the horns, and makes the “ upper fork ” of the horns “ hooked.” Whoever had not seen the pedestals denuded of hair would take them to be cylindric, notwithstanding their really strong lateral compression : and, as the tips of the horns are—at least in some old males—strongly curved inwards and backwards, there is room to say that the “ upper fork is hooked,” though I cannot admire the mode of expression ; because the insignificancy of the frontal fork or forks makes the expression “ upper fork ” as applied to the beam or trunk of the horns peculiarly apt to mislead. I have already intimated that the trifurcation of the horns is probably not a general or permanent characteristic. SHAW observes, that “ that which chiefly distinguishes the *Cervus Muntjac* is the appearance of three longitudinal, subcutaneous ribs, extending from the horns to the eyes.” The three ribs in question are, I suppose, the two frontal fissures, and their intervallary crease, which last, in the *dry skin*, presents almost as decided an indentation and apparent peculiarity of structure as the fissures on either side of it ; owing chiefly to the constant habit the living animal has of dilating the fissures, whereby the skin of

the forehead, contracted on either side by their dilatation, forms a strong crease between them. Nor, however strange it may at first sound to one who has beheld the living animal to hear that these "ribs" run from "horns to eyes," is the thing at all difficult of solution by means of an ill-dried, distorted, skin. What is meant by the thickening of the pedestals at top, and their having the appearance of a rose *after* the horns are forced off, I cannot divine; unless, in the particular case, the horns should have been forced from the pedestals, leaving their own marginal protuberance or burr, attached to the pedestals. In one of BUFFON'S Supplements it seems the *Cervus Muntjac* is described as of a grayish-brown colour: if this be just, *Cervus Muntjac* will constitute, probably, a distinct species from *Ratwa*; and I cannot help thinking that, in such case, the two ought to be, sectionally at least, separated from *Cervus*. I have no late work on Mammalia to refer to, and must crave pardon therefore, if I have been anticipated in regard to that point; and perhaps also for the length of this paper; which yet should find its excuse in the acknowledged futility of summary descriptions of new and foreign animals. The following are the dimensions and size of a male *Ratwa*, which lately died in my possession.

	<i>Ft.</i>	<i>In.</i>
Tip of nose to root of tail,.....	3	4½
Head, length of,.....	0	8½
Tail, ditto, to end of hair,.....	0	7½
Height of animal, at shoulder,	1	7½
Utmost vertical measure of the head,	0	3½
Depth of chest,.....	0	8½
Length of fore leg, to elbow,.....	1	1½
Ditto of hind ditto, to corresponding joint,	1	3½
Ditto of ears,.....	0	4½
Ditto of pedestals, above the skull,.....	0	4
Ditto of horns,.....	0	3½
Weight, 40 lbs...to 36 lbs.		



Head of the RATWA DEER of Nepal.

N O T E

CONTAINING FURTHER INFORMATION RESPECTING THE OVIS NAYAUR.

Since the paper on the *Ovis Nayaaur* was written, I have received a complete stuffed skin, but sadly distorted and injured, of a young male *Nayaaur*. Though the animal when he died was not above eight months' old, he must have measured four feet in length from the nape to the insertion of the tail, and nearly three in height at the shoulder. He has a double coat exactly of the same character as, and rather thicker and longer than the *Chirú's*; whence it follows that the slight differences observed upon in the course of the paper were only the consequence of confinement, change of climate, and perhaps sex also, in respect to the *Nayaaur*. From much conversation that I had with the *Bhotea* who brought me the skin of the young male *Nayaaur*, I now incline to believe that I was mistaken in supposing there are two species of wild sheep in these regions. The *Bharal* of one dialect is probably the *Nayaaur* of another; and the *Himalayan* wild sheep, most likely, only a variety of that widely diffused species, *Ovis Argali*; though I confess I cannot reconcile LINNÆUS' or SHAW'S descriptions of the horns of the *Nayaaur*. The young *Nayaaur* just received has the wool and greater part of the hair, beneath the surface, dull purplish gray slaty; merged in more superficial hues of rusty brown, above, and of impure hoary, below. The lips and inferior surface of the head, and insides of the shoulders and thighs, pure white: superior surface of the head, like the body above, but paler. no dark marks on the limbs, flanks or forehead, as in the female: neither this young male nor the female before described, have any appearance of that peculiar elongation of the hair upon the pectoral surface of the neck for which *O. Argali* is conspicuous.—But the circumstance is no way decisive, owing to the youth of the one and the feminine gender of the other—such appendages most usually appertaining exclusively to mature males. As the

young *Nayaur* now spoken of was taken in midwinter and died immediately, his coat must exhibit the full winter raiment of the species. The hair is about two inches long, and so thickly set on as to stand erect from the skin, in its ascent from which the hair is accompanied about half way by a spare-fleece of fine wool. A larger quantity of the same material lies closely applied to the skin: but the whole quantity of the wool is much less than that of the hair. The horns, though small, have exactly the form already described and figured, and justly referred to the male *Nayaur*, as I have now satisfactorily ascertained.

IX.

SHORT SKETCH OF THE GEOLOGY OF PULO PINANG AND THE NEIGHBOURING ISLANDS, WITH A MAP AND SECTIONS.

By T. WARD, Esq.

ASSISTANT SURGEON MADRAS ESTABLISHMENT

THE geographical situation, the extent and general appearance of Prince of Wales' Island are well known, and it will not be necessary to dwell upon them here, more especially as they are included in the accompanying Map.

PINANG may be described as being formed of a group of hills occupying about two-thirds of its extent, running through its centre from north to south, and having a plain on its eastern and western sides. The hills, thickly covered with lofty forest on all sides, seem at first sight so irregularly grouped, as to defy all arrangement; but on more accurate examination,

they may be divided into three principal chains, commencing at the north, gradually approaching towards the south, where they form one narrow barrier between the two sides of the island, branching off at last, along its southern extremity, at right angles, east and west. The middle chain, including the western hill and Mount Elvira, is that of greatest elevation, being about two thousand five hundred feet above the level of the sea. They are all loftiest towards the north, decreasing gradually as they advance southward. Between the terminations of the chains towards the north are deep bays and sloping vallies, filled with alluvial deposit. The greatest diameter of each hill is from north to south. The general outline is rather blunt and ridged, presenting no very bold peaks or points. Some of the lower hills are obtusely conical. Besides the principal group above described, there runs a small chain parallel to the east coast of the island, behind the Nutmeg Plantations at *Glugor*, of an elevation varying from six hundred to eight hundred feet, uniting with the great range near its southern extremity. There are also some isolated hills along the coast, the principal of which are Mount Erskine, Mount Olivia, and Mount Albina.

The valleys are not deep; few of them have very abrupt, and none, precipitous sides. The whole group, or rather series of chains, is so closely covered with forest, that not a bare spot is visible, except where the industry of man has been exerted. The height is not sufficiently great to produce much effect upon the nature of the vegetation; but small as it comparatively is, towards the summits, the palms and ferns increase in number, and the forest in general becomes more stunted, though even on the highest point are to be seen some magnificent timber trees. An arborescent fern of great beauty, rising to the height of from fifteen to twenty feet, is met with only on the great hill at a considerable elevation.

The soil of the hills is a reddish light sandy clay from the decomposition of the granite composing them, the process of which may be seen going on, wherever roads have been cut below the surface. It is seldom more than eight feet in depth, most frequently less, and the vegetable mould above it is from six to twelve inches. There is little gravel and no fragments, except occasionally of quartz, probably from exposed veins.

The whole of the group of hills, and indeed every rocky or elevated part of Pinang, is composed of granite. No other mountain rock occurs in immediate connection with it. It varies in grain, in colour, and occasionally in the proportion of its ingredients. It is every where traversed by veins of quartz and quartz-rock, which are often of large size. Commencing at Fort Cornwallis, and going round the island, first to the north, we find the following varieties: at *Pulo Ticoose* Point, where the beach is rocky, and composed of immense fragments, it is of a fine grain and grey colour, as in specimen No. 54. At *Batu Feringi*, where a small stream forms a magnificent waterfall, and a great mass of rock is exposed, the granite of rather coarse grain (No. 1*) is traversed by a vein of quartz rock (No. 2) resembling primitive sandstone, very hard, and from two feet to two and a half feet in breadth. In it, the stream has formed numerous tub-like cells, some of them two or three feet deep. I have seen some fine specimens of colorless rock crystal, containing crystals of schorl, which were collected here, but I had not the good fortune to meet with any on my visits. At the east point of *Tuloh Bohang*, the granite is grey and coarse grained (No. 3). At the west point of it, it is of a fine grain and of a slightly greenish colour. On the beach, to the west of *Kúcha Múka*, a small village on the north side of the island, among the rolled

* The figures throughout refer to the numbers of the specimens herewith sent.

masses of granite are some with beautiful veins and imbedded crystals of quartz, and prismatic crystals and amorphous portions of hornblende! (No. 5). Specimens of these, of good size, were, with difficulty, broken off; and indeed to shew them in perfection, it would be requisite to carry away the rolled masses entire. No. 6, is a specimen of the granite found opposite Saddle Island, of moderately fine grain, and containing a large proportion of mica. On the south-west the granite, containing a large proportion of felspar and quartz, is nearly of a whitish colour—(No. 16). At night, from reflecting the moon's rays, it is observed to glisten* at the distance of more than a mile. Imbedded in it, we found a globule of fine grained black granite, containing abundance of mica (No. 17). The whole of the south side of the Island is composed of a coarse brownish granite (No. 18). On the south-east point opposite *Pulo Rimau*, it occurs again of a grey colour (No. 19). These different varieties found along the coast, occur also in the body of the mountains, and it has therefore been considered unnecessary to transmit specimens taken from the interior.

* The east and south-west plains are entirely of alluvial formation, probably in great measure formed by the detritus of the mountains washed down and collected through the lapse of ages. At first sight of the east plain particularly, which juts in a triangular form into the narrow strait between the Island, and the Quedah coast, and on which are built George Town, the Fort, the various public buildings and the habitations of the English residents, the geologist is impressed with the idea that the sea must have at one time covered it and washed the base of the mountains. This is confirmed in some measure by the phenomena observable on the opposite shore of Quedah, where Captain Low has traced the successive deposits of

* Some of the following remarks on the plains, rivulets, water, &c. have already appeared in my "Contributions to the Medical Topography of Prince of Wales' Island," printed by the Pinang Government.

alluvial matter, for several miles inland, and the gradual retirement of the ocean indicated by ridges running parallel to the present line of coast. The process of conversion of such a hard material as granite into alluvial matter is distinctly seen on the road to the Great Hill, in the small valley between "Mount Olivia" and the "Highlands of Scotland." The precipitous bank, about sixty or seventy feet in height, presents a mass of red clayey sand, used generally in lieu of gravel for repairing the roads, which is merely decomposed granite as seen in the specimens Nos. 55 and 56, taken from the spot. Notwithstanding this alluvial origin, no organic remains, not even shells, have been found hitherto imbedded in any part of the valley. Query—may not this be accounted for, by the small number of animals which inhabit the island, and by the paucity of shells now in existence along the coast? The indigenous animals are principally birds and insects, and on two tours round the island, I did not discover in all one hundred shells on any part of it.

The soil of the valley is various. Near the point it is sandy, with a surface of about four inches of vegetable mould from decayed leaves and branches of trees. In advancing about a mile into the interior, the ground begins to rise, and the superficial stratum is also a light vegetable mould, about a foot in thickness, resting on the sand. Near the foot of the mountains, the soil becomes rich in many places, and beds of white clay resembling fuller's earth, are found here and there, more especially in *Pulo Ticoose* bay. In those parts of the island, near the sea coast, which are generally overflowed and thickly covered with mangrove, (*Rhizophora*) the soil for a foot in thickness is a rich black mould. Throughout the island it is light, and in most parts is composed of clay, with a large portion of sand, which renders it very porous.

Water, generally speaking of good quality, is to be had in almost every part of the island by digging a few feet below the surface. In some places it is slightly brackish; in others it is tainted by passing over the decayed roots or leaves or branches of trees; and sometimes it is mixed with the clayey particles of the soil over which it runs. There is no large river in the island; the several rills from the mountains collect into two or three rivulets, which traverse the valley in different directions. Their beds are sandy; the water pure as crystal, and of excellent quality, unimpregnated with any deleterious ingredient. I am not aware of the existence of any mineral water in the island.

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Stream tin has been found near Amee's mills, at the east foot of the great hill, and at *Batu Feringhee* on the north side of the island, washed down from the containing veins which have not yet been discovered. Indeed the immense mass of vegetation, which so closely covers the island, that scarcely an exposed portion of rock can be found, renders it extremely difficult to trace them. At both of the above mentioned places, the tin was collected for some time, but the works were given up as the quantity was not sufficient to cover their expence.

Round the island are extensive mud banks, which, on the north and east sides especially, are left uncovered at low water. On the north-east side of the tongue of land, forming the valley, from *Pulo Ticoose* point to Fort Cornwallis, extensive changes have taken place within the last twenty years. Between the outworks of the Fort and the beach there was formerly a space of about one hundred yards occupied by a row of cocoanuts, and a walk along the beach. Now the sea washes the very walls, which are in part destroyed by its encroachments. The houses on the beach also for some distance, are endangered by the same circumstance; the banks have been rapidly diminishing, and the strongest

bulwarks of stakes and stones are necessary for their protection. In *Pulo Ticoose* bay, on the contrary, the sea has been retiring, the mud bank is daily increasing, and the mangrove has been gradually extending itself. It is too likely that some years hence, the bay may be entirely filled up. These changes are probably owing to the tides setting in strongly from the northward and westward. *Pulo Ticoose* point protects the bay from their action, which is exerted in full force upon the Fort point, or *Tanjong*, as it is called by the natives.

The sand along the coast, round the island, is generally whitish and pure: in some places, however, more particularly on the north side, it is nearly black, from the intermixture of numerous small particles of mica.

So much for *Pinang* itself. We now proceed to the neighbouring islands, commencing with those to the northward.

I. *Pulo Ticoose*, or Rat Island, is merely a barren rock of white granite, with a few large canes. It is about a mile from the north east point of *Pinang*, is of small extent, and offers no geological phenomena of any interest.

II. The *Boontings* are four small islands to the north of *Pinang*, arranged in a semi-circular form, the nearest being about fourteen miles, the farthest about twenty-five from Fort Cornwallis. The most remote one, from a fanciful resemblance to a "*femme enceinte*" lying on her back, has received from the natives the name of *Boonting*, a Malay word signifying "pregnant." In connection with this idea, the other islets have derived their appellations. That nearest *Pinang* is called *Beedan*, or "the midwife"; the name of the next is *Panghil*, or the messenger sent to call her,—and behind it is *Sonsong*, or the companion of the messenger.

1.—*Pulo Beedan*, or *Bidan*, is about a mile in length and three-fourths of a mile in breadth, of an elliptical shape, with a bay on its southern side. It is thickly wooded, the trees, as usual, coming in most places down to the water's edge. It may be noticed here once for all, that this circumstance offers an obstacle to the complete investigation of the geological structure of the island round *Pinang*, as it does of *Pinang* itself in some measure. The interior cannot be penetrated, and were it even possible to do so, the closeness of vegetation would shut out all view of the rocks. The observations are thus necessarily limited in most instances to the coast. The beach, on *Pulo Bidan*, near the south-east point, is composed of an argillaceous rock, resembling grey wacké, both lamellar and conglomerate, irregularly intermixed, (Nos. 41 and 42). This seems to dip at a considerable angle to the west; it is entirely covered at high water by the sea, and the outgoings or crop of the strata form sharp ridges, more or less elevated. Rolled masses of ironstone, (No. 43,) are found on it, of various sizes. On the argillaceous rock, rests a mass of limestone stratified, the strata dipping to the south-west at an angle of 45°. It is of a bluish grey colour, (No. 40,) and at first sight seems to have a slaty texture. The colour of some of the strata is nearly black. They are every where traversed by veins of quartz and calcareous spar, irregularly intermingled. The whole island seems to be composed of the same material.

2.—*Pulo Panghil* is a small rather elevated island, about two miles to the northward of the preceding, and celebrated for its turtles, which lay their eggs in the sandy points and bays. The coast is covered with smooth round stones of argillaceous matter, probably rolled over from *Pulo Sonson*; but the body of the island is composed of the same kind of limestone as *Pulo Bidan*, (No. 45). In Turtle-bay, at the distance of ten or twelve yards from the main body of the island, some

isolated strata of grey marble,* (No. 44,) of fine grain, and highly crystallized, dip at an angle of little less than 45° to the westward.

3.—*Pulo Sonsong* is about three miles to the northward of *Pulo Panghil*; a mile and a half in length, and about one broad at its southern extremity. At the landing place, a small sandy point, we observed some masses of coral rock, close to the beach, and the whole coast was covered with broken pieces of white coral thrown up by the waves. The island is rocky and bold all round, and as usual thickly covered with wood. The rock (Nos. 46 and 47,) is entirely argillaceous, running in regular strata, at an angle of more than 65° , and dipping to the eastward. On the beach it presents more of the schistose or lamellar structure, (No. 46,) and is every where traversed by veins of quartz, (No. 49,) with a coating of a black substance, (metallic!) On the south and east sides, and apparently forming the lower strata of the island, the rock is of a reddish color and soft, (No. 47). On the west side, which is particularly bold and precipitous, it is of a bluish grey colour, soft and silky in some places, presenting the slaty texture, (No. 48,) but not splitting into thin lamellæ as regular clay-slate does. On this side are numerous caves; and the precipices crowned with lofty trees, the immense fragments of rock, the dashing of the waves against them, and the hollow sound of the water rushing into the caverns, have all an imposing effect on the observer.

4.—*Pulo Boonting*, about four miles north of *Pulo Sonsong*, is of nearly oval shape, thickly covered with wood, about one and a half mile long, and one in breadth at its broadest part. It is precipitous

* This is well adapted for architectural purposes: and is fully equal to that brought from *China* at considerable expence.—I am now aware that its existence in the neighbourhood was known heretofore.

only on its north-west side ; in all other places, the forest comes close down to the shore. There is the channel of a mountain torrent on the north side, choked up with large fragments of rock, at the foot of which is a spring of excellent water. The rocks are entirely granitic, the feldspar of the granite being in a state of decomposition, (No. 50). Large veins of quartz, in some places highly crystallized, traverse them in all directions, (No. 51). Among the rolled masses of the channel above mentioned, are specimens of a greener granite, approaching to primitive greenstone, (No. 52) ; and on the beach were found a few pieces of black limestone, (No. 53,) probably conveyed from *Pulo Beedan* or *Sonsongr*.

Round the whole of the *Boontings* the sea is beautifully clear ; and the coral beds are distinctly visible at a considerable distance below the surface of the water. The only one inhabited is *Pulo Bidan*, in which live, in huts of miserable construction, about twenty Malays, engaged in catching and drying fish for the *Pinang* market. In sailing round these islands, we had a magnificent view of *Quedah* peak, or *Gunong gerai*, on the mainland, which rises to the supposed height of five thousand feet. Its composition, I am informed, is entirely granitic ; its outlines are bold, sharp and pointed ; the sides are steep, rising rapidly from the base ; and it presents one immense dense mass of vegetation, unbroken some here and there by a few precipitous white crags. By the aid of the glass, we discovered the channel of a mountain torrent, which, in the rainy season, must form splendid cascades in its course. It has never been ascended by Europeans, and so great is the jealousy of the *Siamese* government, in whose territories it is, that it is not likely it ever will be. The whole of the coast below it, seems one flat uncultivated plain, covered with mangrove, extending a considerable way inland.

III. *Pigeon Island*, situated near the southern extremity of the west side of *Pulo Pinang*, is of small size, and thickly covered with jungle. The rocks at the base, from the action of water, present some most fantastic forms; now, like a huge wall standing apart from the rest, now, like a Martello tower; and sometimes like a piece of Hindu sculpture from *Mahabalipuram* or the caves of *Elora*. It is entirely composed of coarse grey granite, with a large proportion of mica, (No. 6.)

IV. *Saddle Island*, or *Pulo Kudit*, about two miles distant from the south-west point of *Pinang*, is about two miles in circumference, being three-fourths of a mile long and one-fourth broad. Like all the other islets we visited, it is thickly covered with jungle and a few forest trees. On its north side these approach within a few feet of the water. The south and west sides are bold and rocky, the rock in some places being nearly perpendicular, and on the west side there is a deep bay, where several prows might lurk in safety. All round are numerous caves and cave-like fissures, into which the sea rushes with a hollow sound. The constant action of the water has so much worn the rocks, close to the edge, that they present at first sight the appearance of lava. At low water mark a great quantity of coarse coral is to be found, which is collected and removed by the lime-burners, in lieu of limestone. The geological structure of the island resembles that of *Pulo Sonson*, formerly described. It is a mass of argillaceous schist of various colours, according to the greater or less action of the weather, but principally grey, bluish, and red, amorphous in many places, but presenting a laminar, and even fissile slaty texture in some, especially on the east side. It is distinctly stratified throughout; the strata running north-west and south-east, at an angle of about sixty degrees. Near the beach on the east side, the out-croppings of the strata, as on *Pulo Sonson*, form sharp ridges; the rock is soft and of a reddish colour, (No. 8,) traversed by veins of quartz, and of a metallic matter(?) In some

places the veins appear to be of quartz, mica, and chlorite blended together, (No. 9). The body of the rock on this side, above the red material, is an amorphous grey-wacke looking substance, resembling old sand-stone, (No. 7). Above this again is the more slaty-looking rock, (No. 12,) resembling clay-slate. On the south-east side, it seems entirely composed of the red argillaceous rock above mentioned, (Nos. 10. and 11). On the south-west and west sides of the island, from the precipitous nature of the coast, the structure is easily noticed. The rock is entirely like clay slate, (No. 12,) presenting more or less of the laminar structure, slaty in some places, as marked in No. 15. In some parts there is a bending in the strata, similar to that sometimes observed in gneiss; thus



The rock is traversed by veins of quartz of about three inches in breadth, (No. 13,) and of a substance like iron-stone, (No. 14,) which also runs in thin laminar beds through the slate. In the rolled masses, near the beach on the east side, are observed portions of indurated clay, tinged with chlorite.

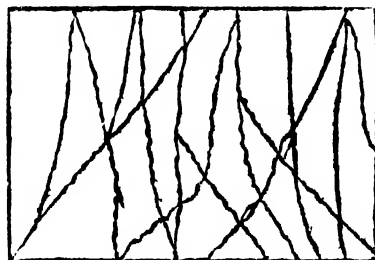
V. *Pulo Rimau* is situated at the south-east corner of *Pinang*, from which it is distant about three-quarters of a mile. It is of an oblong shape, about a mile in length, and one-third of a mile in breadth; bold and rocky except on the north side; covered as usual with wood, and composed entirely of grey granite of a fine grain, (No. 20). On the south side, the rocks are rather fantastically shaped. One at a distance exactly resembles the gable of a house. They were all exceedingly hard; and with a good sized hammer, I could with difficulty break off specimens of proper size. Near the centre of the south side of the island, a curious appearance presents itself. Veins of from one and a half to two feet in breadth, of quartz rock (Nos. 22 and 23,) traverse the granite in different directions. The walls of the veins are of a red colour, and finely crystallized, (No. 24).

The granite is more compact and finer grained, as if compressed by the quartz rock, while in a semifluid state. Veins of red granite, and bed-like masses of it are observed in the neighbourhood, (No. 21). In the old stockade on the north side, we saw a rolled mass of primitive greenstone, (No. 25.), probably part of the ballast of some vessel, as none like it is to be found *in situ*, near *Pinang*.

VI. *Pulo Jerajah* is the largest and loftiest of the islands round *Pinang*, from the east coast of which it is distant about three-quarters of a mile. It is about two and a half miles in length, and nearly a mile in breadth at its broadest part. Its greatest height is at its north end, where the hill is between three hundred and four hundred feet above the level of the sea. It is entirely composed of fine grey granite, with a small proportion of mica, and is of no interest in a geological point of view. The soil is a fine red clay, and the trees grow to a great height, with remarkably luxuriant foliage.

VII. *Pulo Kra*. Two islands close to the main land of the *Malayan* peninsula, near *Batta Kawang*, are so named: they are separated from each other by a narrow channel: each is about a mile long, and about four hundred yards in breadth, rather lofty and thickly covered with wood. Their geological structure resembles that of Saddle island, above described, distant from them fully thirteen miles, with *Pulo Rimau*, of granite formation, between them. The principal rock of the northernmost, *Pulo Kra*, is a kind of argillaceous schist, which is of a laminar structure, and disposed in strata dipping at an angle of about forty-five degrees to the south-east; traversed by veins of quartz, with a crust apparently of metallic matter running down in long black perpendicular lines along the face of the rock, occasionally crossing each other in a net-work fashion; thus—

It is of various colours and consistence, probably as it has been more or less subjected to the action of the weather. It is sometimes greyish white, (Nos. 27, 28, and 31.) sometimes reddish, (No. 30.) sometimes blue, more or less deep, Nos. 26 and 29). Every where it presents the laminar



structure, and splits into tables when struck with the hammer. The veins vary from half an inch to one and a half inch in thickness, and the quartz in them seems to be broken in pieces, between which is observed a metallic(?) crust, (Nos. 32 and 33). The beach is stony and clayey, different from that of the granite island, which we invariably found either rocky, sandy or gravelly. At low water mark, the quartz veins form a curious cancellated appearance. The softer rock between them having been destroyed by the action of the water, they rise in sharp lines considerably above the level of the clay, and are, in some places, scarcely passable without danger of having the feet cut or bruised. Beds and rolled masses of iron-stone were seen along the coast, near the north-west corner more especially; the former dipping at an angle of about 52° . The rolled masses are of considerable size, some being twelve or fourteen feet high, and as many in breadth, looking, at first sight, like volcanic rocks, from their burnt and cancellated appearance. They are formed of a kind of jaspery iron-ore, containing numerous drusy cavities, coated with semi-globular crusts of chalcedony and yellow ochre, some of the specimens of which are very beautiful, (No. 34). The specific gravity of it is 3.000. It strongly resembles, in all its characters, the mineral substance described and figured by Mr. SOWERBY, in the 5th volume of his *British Mineralogy*, page 173. tab. 494, under the name of "Burnt rock." No. 35 represents another ore of iron, of specific gravity 3.640, found also in rolled masses on the coast, from which that valuable metal might be obtained in abundance. In some places, by the action of the water, the softer iron-stone has been converted into a fine yellow ochre, which might be used in painting. The whole of the west side of north *Pulo Kra* is rather bold and rocky, in some places even precipitous; and here and there are deep caves. Along the shore are found numerous sea slugs, or *Holothuria*, and the beautifully polished and variegated *Cypræa* shell, besides coral and sponges of various kinds.

Near the centre of this side, about one hundred yards from the shore, is a small detached rock, resembling, at a distance, the ruins of an Indian Pagoda, entirely composed of a soft red clay, impregnated with iron, (No. 37.) similar to what is called *Gerú* by the natives of India, and which, like it, might be used as a coarse paint. The lowest stratum of the southernmost *Pulo Kra*, is a very hard compound rock, which, for want of a better appellation, I have called grey wacke, composed seemingly of quartz and felspar, very compact and of a blackish blue colour, traversed by numerous veins of quartz, large and small, in every direction, (No. 38). The upper rock is the same argillaceous schist as that composing the northernmost. This structure is well seen at the south-west point of the Island.

Batta Kawang, on the main-land less than a mile cross from *Pulo Kra*, is composed entirely of granite. It is a hill about two hundred and fifty or three hundred feet high. Behind it are extensive sugar plantations. The soil is a fine rich clay mixed with sand. On the east side of the hill, beds of potter's clay occur, from which the coarse conical pots, used in the manufacture of sugar, are made. The small hills along the coast of the main-land opposite *Pinang*, are, I understand, entirely composed of granite. On this subject, however, I shall not enlarge, as Captain Low has already published an account of their structure in the First Volume of the Transactions of the Physical Class. For the most part the ground is alluvial, and, as stated by Mr. FINLAYSON, in his account of the Mission to *Siam*, in some places, resembles peat-moss.

Such were the observations which I made on two tours round this Island, in which every part described was carefully and minutely examined. Specimens of the rocks accompany, which speak for themselves. I am unwilling to obtrude my crude remarks on the Society, but I think

the formation round *Pinang*, will be found entirely primitive, though some of the rocks have very little of the appearance of that class. The total absence of organic remains of any kind, the great inclination of the strata, and their immediate connection with granite, I think, lead to this conclusion. The accompanying geological sections will exhibit at one view the succession and arrangement of the strata. In the direction south and north from *Pulo Riman* to *Pulo Boonting*, a distance of thirty-five miles, we first find granite, then limestone resting on argillaceous rock, then argillaceous schist, and again granite. In the direction from west to east, from *Saddle Island* to *Butta Kawang*, a distance of fourteen miles, we find argillaceous schist, then granite, then argillaceous schist, and again granite.

Should the investigation not prove valuable in a geological point of view, it has at least extended our knowledge of the resources of *Pinang*, by the discovery of the existence of two valuable mineral substances—limestone, including marble, and iron ore, which, should this station ever recover its former importance in commerce, may be of considerable utility.

Pinang, October 18, 1831.

SUPPLEMENTARY NOTE ON THE GEOLOGY OF THE ELEPHANT ROCK, IN THE QUEDAH COUNTRY.

DURING a visit which I made in November last to the capital of *Quedah*, I had an opportunity of examining a remarkable rock, called by the Natives *Gunong Giriyan*, but better known by the name of “the Elephant,” given to it by navigators, by whom it is reckoned an excellent land mark. As it has not been hitherto described, and as it is in some measure connected with my former paper, I hope the following brief description of it may not be uninteresting to the Society.

The country, north of *Quedah* peak, is an immense plain, nearly level with the sea, covered near the coast with rising mangrove, with a very gentle elevation, and bounded to the east by a small chain of hills about from sixteen to twenty miles inland. The breadth of the belt of mangrove along the coast varies from half a mile to a mile. This is succeeded by a narrower one of *ataps*, behind which the country is richly cultivated, laid out in rice grounds, broken every two or three miles by natural boundaries of forest, left most probably when it was originally cleared. The soil is a rich whitish clay, mixed with sand. From the above described plain, at a distance of about six miles from the sea, and about twenty-four in a northerly direction from the northernmost *Pulo Boonting*, rises abruptly the Elephant rock ; no hill or other elevated spot being within several miles of it. It is of an oblong shape, apparently about a mile in length from north-west to south-east, and half a mile in breadth : presenting on every side bold and craggy precipices, between three and four hundred feet in height ; lofty columnar and needle-like masses being here and there detached from the main body, and shooting up like the spires or turrets of a Cathedral. The top is closely covered with wood, which also rises in some places half way up the precipice, shewing the grey or purplish rocks, in contrast with the foliage, and adding much to its beautiful and romantic appearance. The ground in its immediate neighbourhood is a complete swamp, in which grow a variety of marsh plants which were at this time in flower. A belt of cocoanuts, plantain, betel-nut, and fruit trees of various kinds, extends all round it, and conceals the huts of the Malays which appear to be numerous. A deep ditch, either artificial or natural, surrounds the whole, and renders the approach to the rock extremely difficult, even to elephants, with which the Rajah of *Ligore* had kindly furnished us.

It was the object of our guides to shew us the caves with which the rock abounds, and which, when *Quedah* was of greater consequence than it now is, made it a place of common resort for the natives, more

especially the *Chuliah* visitors, who seem to have looked upon it with some degree of religious veneration. We succeeded in crossing the ditch, the elephant sometimes being nearly up to the howdah in mud, and having passed through the cocoanut grove found ourselves near one of the caves. It was not deep, and was formed merely by the over-hanging of the rock. We knocked off some specimens here, and found it to be limestone, close grained, of a dark smoke grey colour, (No. 1). In some places the grain was coarser, the colour deeper; sometimes brownish with minute veins of calcareous spar running through it, (No. 2). Numerous stalactitical masses of a dirty white colour and of immense size, hung from the face of the rock and from the roof of the cave, and when struck with a hammer, gave out a peculiar hollow ringing sound—specimens of these will be found in No. 3 of the series.

Near to this cave there is another, not very deep, but of immense height, the light penetrating at top, through an opening, apparently half way up the precipice. Between these two extending along the base of the rock for some distance, rising a few feet above the surface of the soil, and resting on the limestone, is a bed of reddish yellow cellular calcareous breccia, containing small angular portions of a deep red argillaceous substance resembling that composing *Pulo Sonson*, formerly described, along with small shells and pieces of coral, (Nos. 4, 5, and 6). In No. 4, near the label, is a distinct impression of a fossil shell, apparently a species of *cirrus* (?) and on attentive examination with a magnifier, others much smaller are readily discovered. We saw the breccia only in this spot; but as we found it impossible, from the swampy nature of the soil, to walk along the base of the precipice, it may exist in other places which we did not visit.

The third cave we came to is somewhat further to the northward. It is of splendid extent, apparently one hundred and fifty or two hundred feet in height. The entrance is low, but we ascended a steep slippery road,

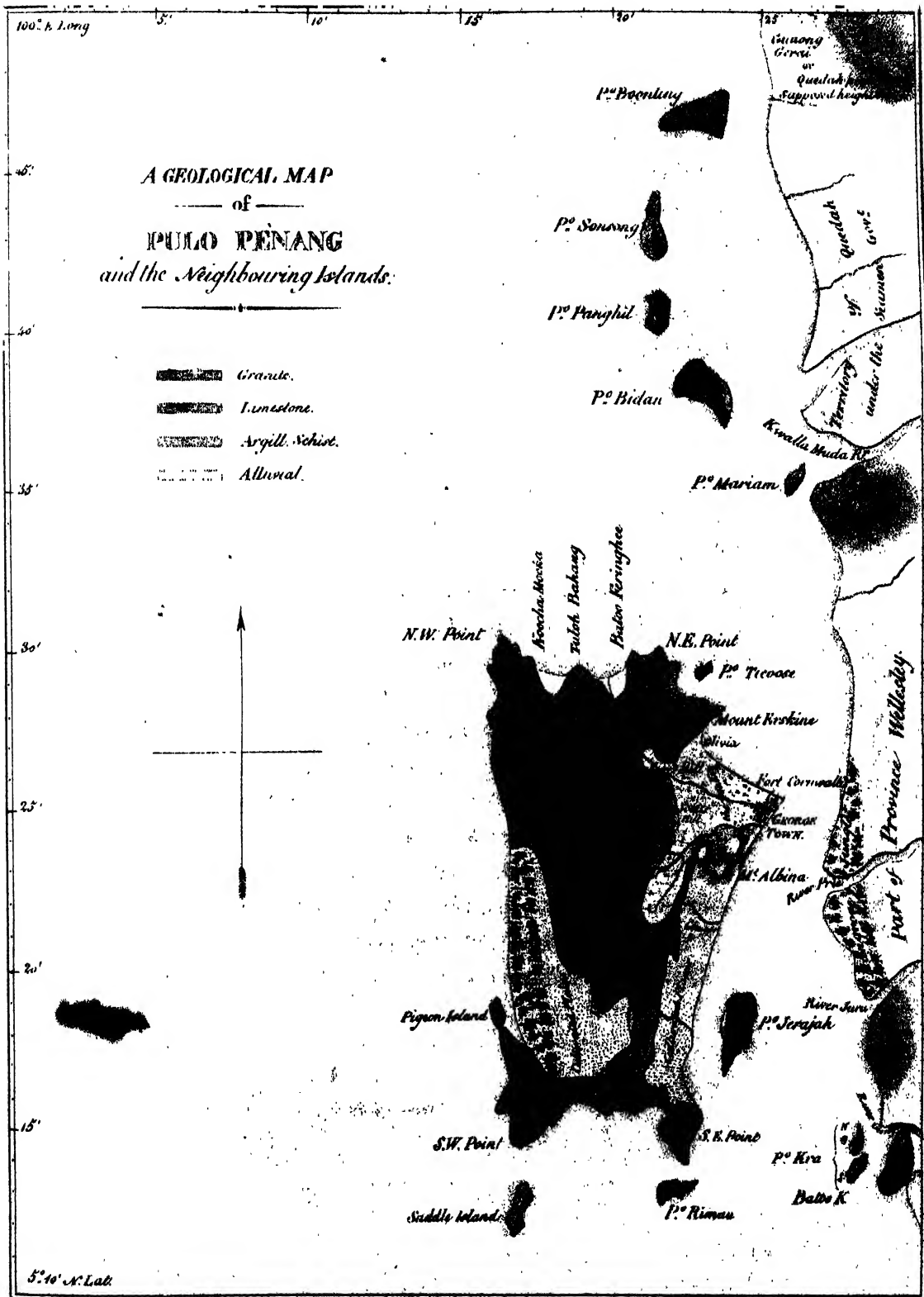
covered with brown calcareous earth, about sixty or seventy feet, at the top of which are numerous stalagmites, one in particular of a large size, perfectly white, and resembling at a distance a full length marble statue standing on a pedestal. The top of one of a smaller size forms No. 7 of the series. From this point the cave branches off in several directions; the torches cast a lurid glare over the nearer walls, occasionally shewing stalactites hanging from the roof, but the darkness of the more distant passages was impenetrable. So far as we could see, the roof and sides were very irregular, the latter being rugged and precipitous.

The fourth cave is situated apparently at the north-west end of the rock. I say apparently; for not having a compass with us, we were obliged to guess in what direction we went, and on that account I cannot be so correct as I could have wished to be. In our way to it, at the foot of a detached limestone rock, at an elevation of from eight to ten feet above the level of the surrounding plain, we found a mass of shells, principally cockles, oysters, and a larger kind of muscle, connected together by calcareous matter, the interstices being filled with soft earth containing numerous smaller shells, (Specimens 8 and 9). The mass was of irregular shape between three and four feet square, and about the same in thickness, perfectly superficial, and not connected in any way with the rocks near it. No appearance of strata of shells was discovered in the neighbourhood. It will rest with better Geologists than myself to determine whether these are to be considered of a fossil nature, and in this enquiry the nature of the small shells, embedded in the soft earth, may be of material use. Leaving the shells, we ascended about thirty feet among large loose fragments of limestone of the same nature as No. 1, and by a small opening in the rock, entered a dark and spacious cave, which, as the eye became gradually accustomed to the change from the previous glare of sunshine, and distinguished the surrounding objects, appeared to us like a splendid gothic Cathedral in ruins. The walls are worn smooth, as if by the action of water, and

covered with a white chalky coating. The roof is dome-like. The stalactitic masses form numerous fret-works, with arched window-like apertures. There are numerous chambers too, and lofty perpendicular passages, some of them admitting light at top, communicating with each other, and producing a pleasing effect when illuminated from within by torches. In places, water is dripping constantly from the roof, but few stalagmites are formed. The floor is nearly level, covered with a brown calcareous earth and with portions of calc-tuff, (No. 10). No. 11 is a specimen of the calcareous sinter, from some of the stalactitic masses.

No sculpture or inscription of any kind was found in the caves. A tradition exists among the natives of the county, that it was at one time surrounded by the sea, and from its general appearance, from the existence of fossil shells in the breccia, and the low nature of the surrounding country, I am inclined to believe that such was the case, and that at no very distant period. It may be remarked also, that it strongly resembles the description of the Limestone Rocks, on the Tenasserim Coast, given by Captain Low.

During the same tour, I had an opportunity also of visiting the nearest range of small hills before mentioned as running parallel with the coast, about sixteen miles inland, and about three miles to the eastward of *Alu Gamuk*, the then residence of the Rajah of *Ligore*. They are so thickly covered with wood, that it is scarcely possible to examine their geological structure. In a few places, however, portions of rock jutted out above the surface, and were found to be formed of a fine kind of sandstone, of which probably the whole range is composed.



XI.

DESCRIPTION

OF THE

BUCEROS HOMRAI OF THE HIMALAYA.

By B. H. HODGSON, Esq.

ACTING RESIDENT AT KATHMANDU.

ORDER, INSESSORES. Tribe, *CONIROSTRES*. Family, *Buceridæ*.

Genus, *Buceros*. Species new.

The Hômrâi *Buceros*. *B. Hômrâi*. (Mihi.) *Habitat*, The Lesser hills overlooking the plains of India, from the Ganges to the Brahmapûtr.

SPECIFIC CHARACTER.

Largest, black, Buceros, with white tail and neck; the wings doubly, and the tail singly barred.

THE Hômrâi *Buceros* (so called by Parbatiahs of *Nepal*,) is the largest species yet discovered of this singular Genus, measuring four feet and a half from the tip of the bill to the end of the tail, and six feet in expanse of wings; and, as all the peculiarities of the Genus are fully developed in this species, their exhibition on so large a scale presents a spectacle calculated to arrest the attention of the most incurious observer of nature.

The Hômrâi tenants the whole of the lower ranges of hills which lie contiguous to the plains, from *Harîdwâr*, on the west, to *Asâm* on the east;

and, following the course of the larger rivers traversing these regions, it penetrates a considerable distance into their mountainous interior; but in such cases always confines itself to the low valleys through which the rivers flow, and never ascends the neighbouring lofty mountains to dwell among them. I have been told, indeed, that the Hômrái is migratory, that he tenants the lower hills only during the winter and spring, and proceeds northward to the vicinity of the snows on the accession of the hot weather, there to reside during the hot months of the year. But I am inclined to doubt the accuracy of this report, though it came from those who are familiar with the bird during his periodical residence in their limited district, and though I have known a tail feather of the species to be picked up in the woods of *Nepal* proper, where the Hômrái certainly does not reside at any season; the only feasible explanation of the circumstance therefore seems to be, that the feather in question was dropped by a passenger,—probably, a casual passenger merely.

The district above alluded to is *Dúmjá*, a small, open, and cultivated tract, at the confluence of the *Rosi* and *Sún Kosi*, in the interior of the mountains, but communicating by the narrow valley of the latter river with the lesser hills and *Táraí*. *Dúmjá* is low and hot, with a climate like that of the *Táraí*. It is abundantly furnished with fine old Burr and Pipal trees (*Ficus Ind.* and *Religiosa*): and these probably form the attraction which draws the Hômrái to the spot: for, he loves the lofty perch they afford and is passionately addicted to their fruit. I have received specimens of this species from the neighbourhood of *Haridvár*, from the valley of the *Raptí*, near where it enters the plains—and from *Dúmjá*; but all procured during the cold season, when alone Europeans can safely enter those malarious tracts. The people of *Dúmjá* assure me that the Hômrái frequents their district exclusively in the cold season, and that he migrates northerly towards the close of February, when the heats become excessive. I cannot imagine the species to be truly migratory, but think

it probable that it resorts to the valleys during the cold weather; to the *proximate* heights, both for coolness and for retirement in the breeding season, during the hot and rainy months of the year: and, it may be easily supposed to move about from district to district, within the general limits assigned to it by nature, in quest of those various fruits which constitute its principal, if not exclusive food; and thence to appear migratory to the peasantry of any one of these districts.

Having weighed attentively the substance of what is said by CUVIER, by his translator, and by SHAW, respecting the habits in respect to food of the birds of this Genus, I am convinced that there is a great want of well ascertained facts on the subject, and that the prevalent opinion which holds that these birds are, in the main, carnivorous, and feed principally upon small birds, rats and mice, lizards, frogs and even carrion, is erroneous. Mr. GRIFFITH is assuredly mistaken in the supposition "that they do not, in a natural state, *ever take fruit*." CUVIER, II. 431. Aves. *Imp. Oct. Edi.*

Of the four species with which I am acquainted, I have myself seen two take fruit, in the wild state; and, having subsequently shot them, have found their stomachs filled *exclusively* with fruit.* The remaining two species I never beheld, at liberty, but have kept them, in confinement for months. Both of these showed a great aversion to the frogs and lizards which, in conformity with the prevalent opinion as to their habits, I, at first, offered them. Both always refused to touch mice, rats, or birds; but without manifesting any disgust at the sight of them: and, lastly, both were fed entirely, after testing their palates, upon fruits and boiled rice, as that sort of food which was found to be most agreeable to

* A common Indian species, different from either of these, was described in the Asiatic Society's Transactions so long ago as the time of Sir W. JONES; it is stated to be frugivorous in the state of nature, and to feed upon the nux vomica, voraciously, so long as such food is procurable. Mr. STIRLING notices the same fact in his account of Cuttack, in the 16th vol. of the Researches.

them, though both would still eat fresh good meat, either raw or dressed, when vegetable diet was not within their reach.

No offensive odour exhaled from the bodies of any of these four species, and the flesh of all was wholesome and pleasantly flavoured; facts which seem to me decisive as to their *never* feeding on carrion, or even, on such living animals as lizards and frogs.

Is there a single bird or beast among the *carnivora*, the flesh of which is wholesome and agreeable to our taste !

With respect to rats, mice, and small birds, it appears to me that so awkward and inagile a creature as the Buceros (any of the species) must soon die of hunger if he were obliged to sustain himself by the capture of such nimble prey.

Indeed, the whole *external* structure of the birds of this Genus affords a strong presumption against their being carnivora—except in the *meanest* sense: and against their feeding on unclean reptiles and carrion, the absence of offensive odour from their bodies and the wholesomeness of their flesh, to my judgment, are conclusive.

What arguments might be drawn on either side from their *internal* structure I am not anatomist enough to say, and I regret I could not afford Dr. BRAMLEY* an opportunity of judging. The character of the stomach and intestines of a large species which forms the subject of the

* To the kindness of this gentleman I am indebted for the anatomical observations upon the Hômrâi which are given in the sequel. Imperfect though they be (circumstances not admitting of a regular dissection of the bird) they will I am sure be acceptable and highly valued by every true ornithologist—most works on the subject, and especially English works, being sadly deficient in this important kind of information.

present paper is, I believe, doubtful : but I can only say that the stomach is single, simple, pretty capacious, thin in its coats, and possessed of very moderate rugosity on its internal surface ; and that the intestines are rather less than three times the length of the body, from the occiput to the rump ; not obviously distinguishable, by difference of size or otherwise, in the different parts ; and of such capacity or diameter as just to admit the insertion of the fore finger. I fear that the foregoing remarks respecting the habits in respect to food of the birds of this singular Genus will, to some, appear tedious and prolix. But whoever is aware of the strict analogy between structure and habits which prevails throughout animated nature, will receive indulgently every attempt to remove errors as well as to contribute facts relative to the most important of the habits of a large groupe of birds which are so singularly formed that we are apt to regard their structure as monstrous and anomalous.

I proceed now with the description of the species before me, of which I possess ten specimens, showing both sexes in maturity, and the young in various stages of progression towards it. From a comparison of these I am led to conclude that the body of the Hômrâi does not reach its full size under two or three years, and that the bill and casque, especially the latter, are not perfectly developed in less than four or five years.

At birth, the young have no casque. The developement of this appendage to the bill commences from behind ; and, in the posterior part, is tolerably distinct as to form by the close of the first year ; whilst, anteriorly, there is no distinction but that of colour between the casque and the ridge of the bill. In the second year, the fore part of the casque begins to rise and spread itself out above the bill ; but does not acquire its full dimensions and characteristic shape till the fourth or fifth year, as will be more particularly noticed hereafter in speaking of the young.

This species is gregarious, like most others of the Genus; of staid and serious manners and motions; full of confidence and quietness; and seeming to prefer the few open and cultivated spots in the wilds it inhabits—which spots are usually limited to the banks of rivers. There, perched on the top of some huge, fantastic *Bar* tree, you shall see this large, grotesque, and solemn bird sit motionless for hours, with his neck concealed between the high shoulders of his wings, and his body sunk upon his tarsi; the very type and emblem of the orient world!

Occasionally, he will take a short flight accompanied by one or two companions (for he is a social bird,) to some other high tree; never, so far as I have observed, alighting on the ground, nor on a low tree. Twenty or thirty birds are commonly found in the same immediate vicinity—six or eight, upon the same tree, if it be large. And they will continue perched for hours with the immoveable gravity of judges, now and then exchanging a few syllables in the most subdued tone of a voice as uncouth as their forms and manners.

This subdued articulation is not louder than, and is similar in character with, the low croaking of a bull frog. But, if the remorseless gunner intrude upon this solemn congress and bring down, without mortally wounding one of its members, the clamours of the captive bird will utterly amaze him. I cannot liken this vehement vociferation to any thing but the braying of a jackass:—its power is extraordinary, and is the consequence of an unusually osseous structure of the rings of the trachæa and of the larynx. The *Hômrái* flies with his neck stretched out, his legs retracted, and his tail levelled and somewhat expanded. His flight is straight and laborious, with heavy uniform frequent motion of his wings, which, though ample in size, have not apparently a corresponding degree of energy:—I presume so, from the short, straight, and laborious flight of the *Hômrái*; and Dr. BRAMLEY infers the same thing from the lax concatenation of the vertebræ of his back.

With respect to food, my impression is that the Hômrái is almost exclusively frugivorous. That he is altogether so, *at certain seasons*, is unquestionable; for, out of six birds which I opened in January and February, there was not one the stomach of which contained a single particle of any thing but the fruit of the *Pipal* tree.

When and how the Hômrái nidificates, I cannot ascertain: but I presume that his habits in respect to breeding are similar to those of the *Buceros Nipalensis*, a species of nearly equal size, tenanted the same region which I described four years ago in the Society's Transactions. And it may be observed, that this peculiar nidification explains the serious injury done to the bill; which nothing that is known of the bird's habits in respect to food will, in the least, account for. The mature male of the Hômrái species measures four and a half feet long, and six feet in width between the wings.

The bill is nearly a foot in length, of straight measurement,—considerably more, if measured along the curve; and the tail is one and a half foot. The bill and casque are both extremely large, and bear a close resemblance in their forms to those of the *Bifronted Buceros*. The legs are short and stout, and the feet exhibit the perfection of that peculiar structure which induced CUVIER to separate his Syndactyles from the promiscuous heap of the Passerine birds. The body is full and plump, but very small in proportion to the size of the extremities. The neck is as long as the body, the vertebræ being large in size, though few in number. It is a long, lank bird, of uncompact structure, almost helpless on the ground, and of but limited power on the wing, with feet incapable of grasping, in the raptorial sense, but admirably suited for laying a strong hold upon the larger branches of those tall trees in which the species seem to spend nearly their whole lives—feeding and roosting in one and the same place, and having no necessity to go abroad in search of water, since they never take it.

The bill is extremely large, cleft to the eye, smooth, hard, considerably arched throughout, much compressed, except at the base, where it is as broad nearly as high, the cutting edges broken and separated in the central parts of the bill, closed and even towards the extremities, but not interlocked. The cutting edges are composed of a separate brittle substance, which, in the perfect bill, is furnished with serrations. But as these serrations, together with most of the substance containing them, are not developed in the young bird, and are soon, for the most part, destroyed, nor ever afterwards replaced, in the maturer one, it is as difficult precisely to define them as to conceive the purpose for which they were intended.

The hard substance in which these serrations are cut, likewise lines the whole inside of the bill, and is never itself entirely destroyed on the cutting edges, though the teeth-like processes are: its entrance into the composition of the bill, must give the bill considerable additional power.

The palate is placed near the cutting edge of the upper mandible: in the lower mandible it is remoter, except near the tip, where, as in the upper one, the palate lies in contact with the cutting edges of the bill, both mandibles of which are nearly solid towards their forward extremities. A sharp ridge runs down the entire centre of the inside of either mandible. The upper and lower mandibles are of equal length, and rather sharply pointed.

The casque is rested on the basal part of the bill and on the cranium, passing beyond the posterior boundary of the latter more than an inch and a half. Its most forward point is about four inches before the eye; its most hindward three and three-quarter inches behind it. From the tip of the bill to the forward point of the casque, nine inches. The casque is frail, hollow, very large, flat topped, broader than high, as broad almost before as behind, its upper surface level with the margins, posteriorly dipped between them, and inclined towards the ridge of the bill, anteriorly;

squared behind, concavely crescented before, with the horns of the crescent elevated one inch above the bill, and directed forwards and downwards with a slight curve parallel to the bend of the bill : the posterior edge of the casque, full, rounded, and soft ; the lateral and anterior edges, spare and hard.

The nostrils are small, subtriangular or irregular oval, transversely cleft, placed at the base and top of the bill, where it joins the casque, and covered with incumbent reflected setaceous feathers.

The tongue is fleshy, flat, small, with point entire ; its position, the bottom of the throat.

The head is small ; the parietal and occipital bones, firm and solid ; those of the anterior parts of the skull, cellular and feeble ; the occiput, strikingly defined and furnished with large transverse and vertical cristæ ; the orbits, medial and almost entire. Both eyelids have strong bristly lashes, the upper being the stronger and conspicuously flattened or depressed. The tail is long and rounded slightly, consisting of ten very broad, strong, feathers of nearly equal length, but the laterals somewhat shorter than the centrals, and subgradated from below.

The wings of medial length, high-shouldered, rounded, acuminate, the sixth quill longest ; the fifth and seventh nearly equal to it ; the first and second much smaller, narrowed, sharp, and incurved ; the longest primaries and longest secondaries, equal ; the tertials and scapulars, small.

The legs and feet very stout. The tarsi, low ; knees plumed before ; acrotarsia, brokenly and heavily scutellated ; posterior and lateral surfaces of the tarsi, covered merely with coarse reticulated skin ; the toes, of sub-medial length, depressed, broad, shielded by a single row of transverse

heavy scales, and of strictly gressorial or syndactyle character; the nails, arched, compressed, obtuse.

The dimensions will be given in detail in the sequel. The colours are as follows :

The casque and upper mandible of the bill, deep waxen yellow, merging, more or less, into rich red, on the top of the casque, and towards the tip of the upper mandible; the tip itself, and the lower mandible, ivory white; base of both mandibles, anterior and posterior surface of the casque, a line along the ridge of the bill, its cutting edges, and the whole inner surface of the bill, black; iris, intense crimson; legs, deep obscure green; nails, blackish; naked skin round the eye, full black; body and wings, subterminal bar on the tail, chin, and junction of the head and neck, black—the body above and wings, feebly glossed with green—the rest, unglossed; neck, yellow-tinged white; tail, pure white, with a broad black bar crossing it entirely at the distance of three inches from the lower extremity: all but the two first quill-feathers of the wings, broadly whitened at either extremity; tips of the long coverts, also white, forming altogether two conspicuous white bars on the wings: vent, rump, thighs, legs, and upper and under tail coverts, dirty white. The unctuous secretion from the rump is of a yellow colour; and, either with this, or with a local secretion of the same kind, several of the prime quills are dyed on the white part of them, going to form the upper bar of the wings. Why this spot should be thus dyed, and no other part of the plumage, I cannot imagine; but note the fact, because all my specimens agree in respect to it.

The whole plumage of the head, neck, inferior surface of the body and of the thighs, is lax, discomposed, and more or less setaceous; that of the hind head being also somewhat elongated, forms a slight drooping crest. The crest and the neck feathers, the bird erects partially when

much excited. The female and young of a year old have the legs and plumage coloured exactly like the male; from which the former differs by being smaller; by having the irides of her eyes, pure hoary; the naked skin of the ophthalmic region, pale purpurescent dusky; and lastly, by wanting the black colour which distinguishes the casque, and ridge, cutting edges, and interior surface of the bill, in the male; those parts of the casque and bill of the female, being red, like the subterminal portion of the upper mandible of both sexes. The mature female's bill and casque are shaped like those of the old male, but are both smaller in proportion. The young have the bill much less arched, and thicker in proportion to the length; the cutting edges are entire, void of brittle substance or serration; and there is no casque, or rather the casque has no development or separation from the bill, anteriorly: for, posteriorly, it has both, very soon after birth. In the second year the anterior portion of the casque begins to separate itself from the ridge of the bill, exhibiting a wedge form; the apex of which, gradually receding during the third year, in proportion as the casque acquires more breadth and height in front, comes at length, in the mature state to form the centre of that inward curve or crescent, the ends of which are the *horns* of the old bird's casque. The younger the bird, the narrower the casque in front. Old age alone makes it nearly as broad before as behind. The sketches appended to this paper will complete the illustration of this point, which is of importance as a guard against the multiplication of imaginary species, derived solely from diversities in the shape of the bill and casque. The bill of the young is at first of an uniform pale greenish yellow, with a small portion of black at the base only. Their iris, whatever the sex, is at first, hoary, like the females; and the ophthalmic region, pale dusky. *Posteriorly*, their casque is soon darkened, if they be males—reddened, if they be females: but the black or red space defining the separation of the casque and bill, *anteriorly*, is later manifested; because its manifestation depends upon the development of the casque itself in that the last developed part of it.

The black or red (according to sex) of the cutting edges begins to show itself before the close of the 1st year, and is as abundant in quantity, though less intense in hue, in the 2nd year as ever afterwards. Indeed, the brittle edging of the bill, which is alone thus coloured, no sooner is perfected than it begins to be rapidly destroyed, together with the serration which belongs to it—an enigmatical circumstance—like, indeed, every other connected with the purpose and use of this most remarkable organ.

Dimensions of the mature male and female.

	MALE.	FEMALE.
	<i>Ft. In.</i>	<i>Ft. In.</i>
Tip of bill to end of tail,	4 5½	4 0
Bill, length of,	0 11½	0 10½
Ditto basal height of,	0 3	0 2½
Ditto basal breadth of,	0 2½	0 2½
Length of the casque,	0 7½	0 6
Utmost height of ditto,	0 1½	0 1½
Utmost breadth of ditto,	0 3½	0 3½
Length of the tail,	1 6½	1 6
Expanse of the wings,	5 10	5 5
Length of the tarsi,	0 3½	0 3
Length of central toe and nail,	0 4	0 3½
Weight of the bird,	8½ lbs.	7½ lbs.
Weight of the bill and skull,	8½ oz.	<i>caret.</i>

VALLEY OF NEPAL, *February, 1832.*

REMARKS ON THE SKELETON OF THE HOMRAI BUCEROS.

The Bill consists of horny matter of considerable thickness, which lies in close adaptation with the osseous structure beneath, and is connected with it by means of a membrane, over which numerous small blood vessels are distributed.

The casket, (which is of large dimensions) has also its horny covering, though somewhat different in structure, that of the former being

laminated, and bearing a close resemblance to proper horn, while that of the latter is much thinner, of a fibrous consistence, and nail-like in structure. The edges of the bills, of both mandibles, for about two-thirds of their length from the point, are horny, but the surface is so irregular and jagged, that their appearance leaves no doubt that much of the natural structure has been broken off, by the use which the bird makes of its bill. In consequence of this, when the jaws are closed, there is a considerable vacancy between the cutting edges throughout the whole central portion of the bill. In some specimens in Mr. HODGSON'S Collection the fractures have taken place at such regular intervals, as to give to these parts the appearance of natural indentations.

To entertain this supposition, however, would be erroneous, as there is evident reason to believe that in a bill, which is perfect, the horn by which it is covered does not extend to its edges, but terminates just before it arrives at these, in a substance not very much unlike solid bone. The chief difference from the latter, is, that it is exceedingly brittle in its nature, though it is by no means deficient in compactness.

That this substance borders the edges of both mandibles in their natural state, is confirmed by numerous portions which are here and there left, in all the specimens I have examined. There is, also, a distinct line along the bills denoting the termination of the horn, into this hard structure, which in some individuals is of a red colour, and in others, a black.

There is no trace of reproduction, after a portion has once been destroyed, and so much of it is lost in early life, that in the mature bird, the only portion which remains perfect, is that which is situated nearest the cranium. In six out of seven of these birds which I have examined, all these remaining portions of sound bill, have certain serrations on their edges, which proceed from this hard substance: in none, however, were they arranged

with sufficient regularity, to admit of description, except in the individual from which these notes are chiefly taken. In this four very distinct ones, may be said to exist on the lower mandible, the interval between them being so uniform, and their shape so similar, as (from appearance alone) to warrant the conclusion, that they are natural productions. In the seventh specimen, however, (which was a young bird supposed to have been hatched last rains,) these serrations are not visible in either mandible. Whether (in the perfect bill,) these tooth-like processes always exist, I will not pretend to determine. If they should be found to do so, it would at least, become a matter of question, for what purpose they are destined.

The circumstance of the birds being deprived of a greater portion of the hard substance constituting the edges of the mandibles, in early life, never afterwards to be replaced, is a strong evidence that such formations are not necessary in aiding them to secure their food, moreover their presence would not correspond with the supposed natural habits of birds of this class ; and, furthermore, as there are no corresponding depressions in the opposite jaw, and as the birds live very well without them, it is reasonable to conclude, that the existence of serrations on the edges of the bill must be denied, as necessary formations, while to account for their presence, the exceeding brittleness of the substance on which they are situated deserves consideration.

The osseous structure beneath the horn, as will be apprehended from the enormous size of the bill, is very light, and cellular throughout, The same structure is also observable in the bones, at the base of the skull. The casket on its interior exhibits nothing but innumerable, and minute processes of bony matter, which intercept each other, so as to form a reticular arrangement. The upper mandible is firmly joined to the skull, and admits of no motion whatever. This variety (which is met with in very few birds) may be accounted for in the present species, by the large

casket being fixed to the bill, and resting posteriorly on the vertex of the cranium. If therefore the upper mandible was moveable, the casket would become subject to the same motion. The orbits, when compared with those of most birds, are small. There is no trace of a bony septum between them, but their division is effected by a membranous partition.

The cervical vertebræ are twelve in number. They are articulated to each other by means of small eminences, which constitute real joints. This provision, which is common to all birds, gives to them that peculiar freedom of motion in the neck, which the whole class more or less possess. In the Buceros this motion is considerably restricted, in consequence of the firmness with which the ligaments bind these vertebræ together, particularly the large one which passes along the proterior part of the neck, and attaches itself to the spinous processes.

There are seven dorsal vertebræ—which are articulated to each other by synchondroses, or plane joints. They are all separated, but the first three are so firmly connected by ligamentous structure as scarcely to admit of any motion; the remaining four are more loosely joined.

It may here be noticed, that as the dorsal vertebræ of this bird are all moveable, it becomes a matter of question whether its power of flight is in any way remarkable. Except in birds which do not fly, as the Ostrich, &c. it is by no means common to meet with examples, where the dorsal vertebræ are all separated; two or more of these are generally found to be anchylosed at their spinous processes, or the whole of this part of the spinal column may be rendered fixed and immoveable, by the connecting ligaments being substituted by bone, as is very generally the case in birds possessing any extraordinary activity on the wing, or extensive power of flight.

This immoveable structure of the *dorsal* vertebræ of such birds is believed to be necessary to give support and steadiness to the trunk, during their varied and violent motions in flying; and BLUMENBACH affirms that the want of motion inseparable from it, is compensated by a larger number, and greater mobility of the *cervical* vertebræ.

In consistency with this supposed system of compensation, the Buceros which has dorsal vertebræ capable of considerable motion, has but a small number of cervical vertebræ,* and those rigidly connected. From this structure I infer the limited power of the Buceros on the wing.

The lumbar vertebræ, as is usually met with in birds, are all anchylosed. The remains of the three first are visible, but their total number cannot be ascertained. The tail consists of eight bones. The last of these is the largest, its greatest length measuring $2\frac{1}{4}$ inches by $1\frac{3}{8}$ in breadth.† All the bones have large transverse processes. They have also spinous ones situated posteriorly, and the three last bones, have in addition these processes arising from their anterior surface.

There are seven pairs of ribs, namely, six pairs of true ribs, and one pair false, i. e. not attached to the sternum. The true ribs are joined to the sternum by intermediate bone.

The pelvis is similar in formation to that of birds in general, except in those which have it closed in front. The length of the os innominatum is $4\frac{1}{8}$ inches, and $2\frac{3}{8}$ inches broad.

* This bird has the same number of cervical vertebræ as the raven, and one less than the cock.

† The dimensions of this bone are noticed in consequence of the bird being observed to erect and expand its tail feathers.

The sternum measures in length $4\frac{1}{8}$ inches, and in breadth $2\frac{5}{8}$ inches. The large crista which is situated on its centre and anterior surface is continued down the whole length of the bone—and is elevated above the sternum at its most superior part $1\frac{1}{4}$ inches. At this point is united the os jugale, (merry thought) the cornua of which proceed outwards and upwards, and nearly parallel with the two large clavicles, to meet the scapulae at the point of either shoulder, where these three bones become united by ligament, and form the glenoid cavity of the Humerus.

The wing is composed of the following bones. 1st. The brachium—which measures $5\frac{1}{2}$ inches in length. 2ndly. The two bones of the fore-arm (cubitus) in length $3\frac{1}{2}$ inches. On the largest of these bones are fourteen small prominences, arranged longitudinally, which denote the attachment of the quills of the secondary feathers of the wing. 3rdly. Two small bones of the carpus. One articulated by firm ligamentous structure to the end of the small bone of the fore-arm. The other is attached to the large bone, by means of a long tendon, which is inserted at about the terminal third of this bone, and it is joined to the metacarpus just below its articular surface by ligaments. This bone is situated in the bend of the wing, and plays on the outer condyle of the metacarpus. 4thly. The metacarpus consists of two bones consolidated into one at either extremity, and open in the centre. It measures in length $2\frac{6}{8}$ inches. 5thly. The thumb (false wing) formed of one small bone, articulated to the metacarpus on its edge, and immediately below the carpal joint. 6thly. The two fingers, that which lies on the same line with the thumb, has two phalanges, the other but one.

The Leg. The first of these bones is the femur, in length 4 inches. 2ndly. The tibia and fibula. The former measures $5\frac{1}{2}$ inches in length. The fibula, which can scarcely be said to exist, in most birds, is very

distinct in this. It enters into the formation of the knee joint, and completes the outer border of the articular surface, part of the outer condyle of the femur resting on it.

The breadth of its articular surface is $\frac{3}{8}$ of an inch. From this it is continued down the outer edge of the tibia, but has no osseous connection with this bone, for $2\frac{5}{8}$ inches in its extent, here the two become consolidated, and towards the termination of the bone, above the articulation, a small speculum of bone arises from the tibia, which denotes the termination of the fibula. 3rdly. One metatarsal bone (answers to the tarsus) $2\frac{7}{8}$ inches in length. To this the toes are articulated. There is also another which is attached to the metatarsal bone, by a broad synchondrosis, and proceeds obliquely outwards, for the exclusive attachment of the great toe. This bone has been observed in some birds of the Parrot kind, and I can testify its existence in the foot of the King-fisher. It is difficult to convey an adequate description of its shape. In the present bird (Buceros) it is nearly an inch in length, and half an inch broad at its articulation to the great toe. It has two prominences on its articular surface, resembling condyles, the inner one being twice the size of the outer. To meet these, there are corresponding concavities at the base of the first phalanx of the great toe, by which a very perfect joint is formed. There is a groove in the metatarsus in which the base of the small bone is lodged. 4th. The toes. The great toe has two phalanges. The one next to this has three, the middle toe four, and the last has five.

Memorandum concerning the anatomy of the tongue and vocal organs of the
Hómráí Buceros.

The tongue consists of a small fleshy substance of triangular form, and measures about $\frac{3}{4}$ of an inch in length, by $\frac{1}{2}$ an inch in breadth.

On its superior surface, and towards its base, several small cartilaginous processes are seen with their points directed towards the throat. Its edges, on this part, are also barbed by similar structures.

There are no papillæ observable on its surface, nor can it be considered an organ of taste, since it is so firmly connected to the sheath of the lower mandible, as to admit of little or no elongation even with the aid of considerable force, which I applied very shortly after the bird was shot.

The tongue terminates by a strong fleshy attachment to the os hyoides, and is further connected to this bone, by a process of cartilage which arises from the body, or centre portion, of the latter, and becomes embedded in the muscular structure of the organ to about half its length.

The os hyoides consists of five distinct bony portions ; viz. The body or centre portion, and two pairs of cornua. The first pair of the latter are attached to either side of the body ; at the ends of these commence the second pair, the two being joined together by synchondrosis. Their united length on either side is three inches. The second pair terminate by two round cartilaginous ligaments, which measure $\frac{3}{4}$ of an inch in length.

Besides the cartilaginous process which arises from the body of the os hyoides, and gives attachment to the tongue, there is a similar one which proceeds from its inferior edge, which is loosely bound to the posterior surface of the trachœa by bands of ligamentous structure.

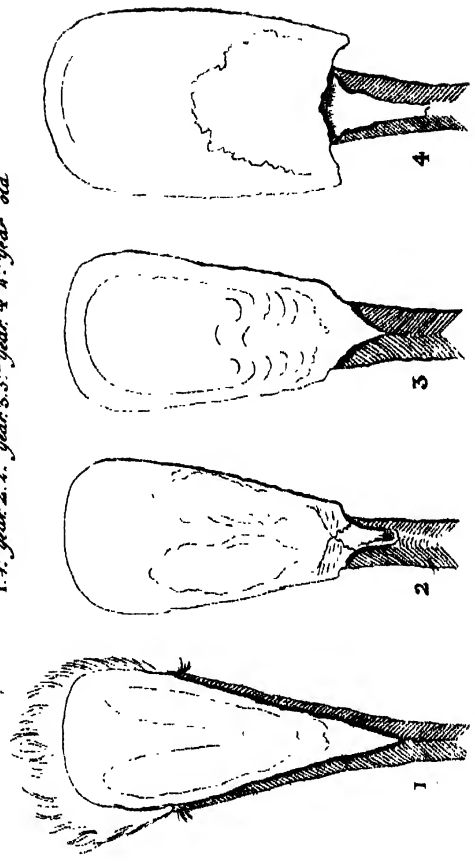
The superior larynx is formed anteriorly and latterally of bone, its posterior part being completed by membrane.

The annuli of the *Trachæa* are all more or less ossified, and there is also a bony addition at the inferior larynx, which latter may probably be the same as that found in some of the Mergansers.

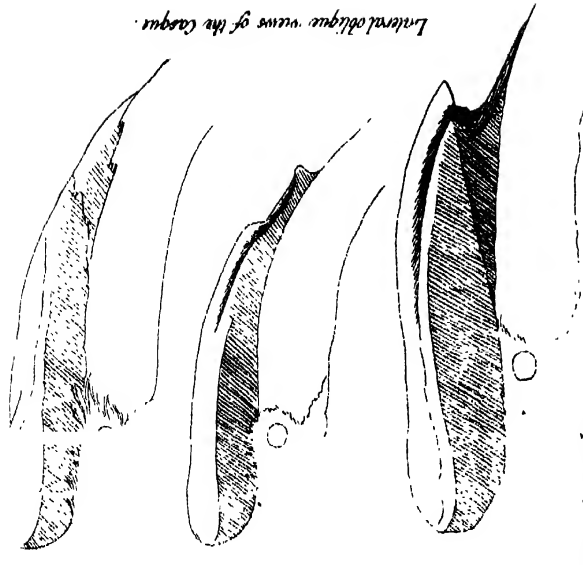
M. J. BRAMLEY.



The Hômrûi Buceros



Views of the Casque from above
 1. 1st year 2. 2nd year 3. 3rd year 4. 4th year old



Lateral-oblique veins of the Casque.

XII.

ON THE
COMPENSATION MEASURING APPARATUS
OF THE
GREAT TRIGONOMETRICAL SURVEY OF INDIA.

BY CAPTAIN EVEREST.

Bengal Artillery,

F.R.S. M.A.S. F.G.S. &c. SURVEYOR GENERAL, AND SUPERINTENDENT OF THE
GREAT TRIGONOMETRICAL SURVEY OF INDIA.

*[Being the substance of a Lecture delivered in illustration of the Measuring Apparatus, before the Physical Class,
on the 11th March, 1831.]*

Nothing seems easier, at first sight, than to measure a straight line. If, for example, it were wanted to ascertain the length of the room we are in, or the table at which we are seated, the mode commonly used on such occasions would be to take a foot rule and try how many feet and inches it was, and this would be quite a sufficient solution, provided that there was no further object in view. But suppose it were necessary, for any particular purpose, to know the exact relative lengths of two rods or bars, one of which had been determined in the national measure of France, and the other in that of Great Britain. Here, at first sight, is a very different state of the case, for the English rod has been measured with a foot rule, and so has the French; but though they should be of perfectly equal size, the lengths would not be expressed by the same number.

Now, therefore, it will be necessary to enquire a little further into first principles; and let us think for a moment what is a foot? The definition of a foot is twelve inches. But what is an inch? Three barley-corns make an inch, as we are told at school; but unless it can be shewn that the ears of barley in France have grains longer than those of England, it will be difficult to shew why the French foot is longer than the English, as it actually is, in the ratio of seventeen to sixteen nearly.

Our enquiries will lead us at last to the conclusion, that what is called the standard yard of Great Britain is not in itself a very determinate quantity; for take several carpenter's rules and compare them, and two of them will hardly ever be found alike; or take several brass Gunter's scales, as they are called, made by different makers, and they will by no means correspond with each other, nor is it easy to conceive how they ever should, for the old standard of reference, which was three grains of dry barley, must vary from causes almost innumerable. Indeed, in respect to national measures we owe no thanks to the wisdom of our ancestors.

Every country in Europe has its own particular measure. We have the Roman palm, the braccio of some parts of Italy, the ruth of Dantzic, and numerous others. Most countries, however, use the term foot, because it is supposed to have some relation to the part of the human frame most easily accessible, and whether it is owing to what are called the degenerate modern days, or whether the foot originally was taken as a standard of reference with a shoe on it, certain it is that twelve of our inches, now-a-days, would be rather a longer foot than suitable to ornament or utility.

It will hardly be credited, yet it is an actual fact, that there are in Europe alone upwards of a hundred different national measures, no two of which had, until lately, their relative values thoroughly known; but if

this should seem matter of surprise, still more extraordinary must the fact appear, that until Captain KATER's experiments, there were measures bearing the same denomination in our own country, none of which corresponded, so that every instrument maker, when he constructed what he called a standard scale, meant his own standard, which he had either arbitrarily fixed for himself or inherited from his predecessor.

The want of a determinate idea as to the measures of antiquity, has always been a subject of perplexity to Historians,—in fact, in consequence of that defect, all the geographical details which we derive from that source are a maze of conjecture for the ingenious to build airy hypotheses in. Perhaps, however, this system, incongruous as it is, might have been sufficient to answer the ordinary purposes of life, and, if the question had never been started respecting the figure of the earth, would, in all probability, have been but little agitated, if at all.

This was at first a mere speculative question : it had been found by M. RICHER, a French mathematician, who went to make astronomical observations at Cayenne in 1672, that the pendulum of his astronomical clock, which had been adjusted to mean time at Paris, lost above two minutes every day, and he was obliged to shorten the pendulum one-tenth of an inch to make it keep time in the latitude of $4^{\circ} 55''$. Such was the state of science at that period, (and we are not yet two centuries removed from it,) that when he drew conclusions from this respecting the diminution of gravity, his opinions were scouted by almost all the Philosophers of Europe. HUYGENS was the first person who gave the subject fair consideration, and as he brought with him an overpowering array of mathematical reasoning, combined with inexhaustible patience, he soon discovered that pendulums must vibrate slower as they approach the equator; but even HUYGENS could not solve the difficulty of assigning the form which the earth must assume. He made what we should call the two

hemispheres consist of two parabolic conoids, the bases of which met at the equator, where there was a ridge formed.

Now, Navigators had gone over the equator, and they knew very well that the line was a mathematical line—that their ship did not strike against, or shew any manifest signs of such a ridge, and besides this, two plumb lines placed on opposite sides of the equator, but near each other, did not shew any sensible difference in their directions, nor did nature on enquiry appear to vary from her usual course of doing nothing abruptly.

Sir ISAAC NEWTON was the first person who gave any solution of this question. In Prop. 19* Book 3d of the Principia, he demonstrates that a homogenous body like the earth might, in consequence of its diurnal motion, form itself into an ellipsoid of revolution, whose Polar axis was to the diameter of the equator as 229 to 230. This solution was the effect of the new arm, then, for the first time, brought to bear upon this disputed point, for unless the law of the variation of gravity inversely as the square of the distance had been previously discovered, no power of analysis ever would have sufficed to elucidate it.

But the demonstration was imperfect like almost all first attempts, and some points were taken for granted which were not mathematically true. We† shall find some of these pointed out by M. CLAIRAUT, one of which is very important to the subject, and consists in the annunciation ‡

* PROPOSITIO XIX.—Est igitur Diameter Terræ secundum æquatorem ad ipsius diametrum per polos ut 230 ad 229—Ideoque cum Terræ semidiameter mediocris juxta mensuram Picarti sit Pedum Parisiensium 19615800 seu miliarum 3923,16 (posito quod miliare sit mensura pedum 5000) terra altior erit ad æquatorem quam ad polos excessu pedum 85472 seu miliarum $17\frac{1}{10}$,

† Il est aisé de voir que ce theoreme est entierement contraire à ce que M. Newton a avancé dans la proposition XX. du troisieme livre des Principes, P. 251, &c. PS. 50.

‡ Liber Tertius Prop. XX. Et propterea terra aliquanto altior est sub æquatore quam pro superiore calculo et densior ad centrum quam in fœdinis prope superficiem.

that an increase of density in the earth, from the surface to the centre, would be attended with a greater protuberance at the equator than in the cases of homogeneity.

As it is not an object to enter into a minute investigation of this abstruse question at present, this part of the subject may be dismissed with the name of M. CLAIRAUT, who first fully considered the question of the figure which a planet must assume with a density gradually increasing from the surface towards the centre.

The theory of Sir ISAAC NEWTON was not well received at first—it impugned the doctrine of the vortices of DESCARTES, which was then in high favor in France. M. PICARD had measured an arc of the meridian in France between Amiens and Malvoisine about $1^{\circ}\frac{1}{3}$ of the quadrant; MM. CASSINI, DE LA HIRE, and others, resumed this, and continued it through the whole extent of France in several sections, which were finished in 1718, and it was found that the lengths of the degrees diminished as the latitudes encreased, which rather tended to give an elongated than an oblate form to the globe. This was afterwards found to result from errors of computation, but since the comparison of contiguous degrees is not the best way to determine with great accuracy so very small a quantity, as the compression would be, the Government of LOUIS XV. resolved on fitting out two expeditions, one of which should measure an arc as near the equator and the other as near the pole as possible.

It was in 1735 that MM. BOUGUER, DE LA CONDAMINE, GODIN, and several assistants and artists on the part of the French Government, accompanied by Dons JUAN and ULLOA, on the part of that of Spain, went to Quito, in Spanish America, and at the same time the northern expedition under MM. MAUPERTUIS, CLAIRAUT, MOUNIER, CAMUS, CELSIUS, and

others went to Torneo in Lapland—permission having been obtained from the Swedish Government for that purpose.

Both these expeditions were fitted out with the best instruments then to be obtained, at the expence of the French Government. The operations under the equator occupied upwards of ten years, and those of the polar circle about two.

One cannot too much admire the determination and constancy with which the French Government seems to have been actuated on that occasion. The *onus probandi* did not lie with them more than with us, perhaps not so much so—nature and fortune had bestowed upon England the greatest philosopher mankind ever saw, and our ancestors must bear the reproach of having neglected as unworthy of them that pre-eminence in science, which had it fallen to the lot of any other nation in Europe, would have been looked on as a high source of pride. It is very true Sir ISAAC NEWTON was recompensed, whilst living, by a lucrative post at the Mint, and it is equally true that monuments have been erected to him in Westminster Abbey, and elsewhere ; but the best monument which a grateful country could have bestowed on this most eminent and distinguished of her sons, would have been to establish the truth of the doctrines he had promulgated by actual experiment, instead of leaving them entirely to the mercy of strangers.

Not to dwell too much upon these preliminary matters, it will now be advisable to explain what the figure of the earth has to do with the subject on which we started, for it is desirable to show that this is not merely a speculative point for the philosopher to amuse himself with in his closet, but one of actual practical utility, according to the conception which I have of the meaning of that term.

If it be conceded that geography is useful—then there is no pure source from which we can draw our elements, but this. Let us measure a distance on the earth's surface by the primitive mode of the drying of a wet leaf,* the more modern method of the duration of a smoking pipe,† by pacing, by chains, by rods, by perambulators; we must (do what we will) for geographical purposes reduce the distances so found to degrees, minutes, and seconds, of latitude and longitude. But unless we know how many miles, or feet, or pipes, go to the degree, the mode of comparison is wanting to complete the reduction.

If the earth were quite spherical, all degrees of latitude would be equal, and all degrees of longitude would vary as the cosines of the latitude, but that is not the case if it be compressed at the poles, for the length of degrees of latitude would then increase as we recede from the equator, and the length of degrees of longitude would cease to vary in the above proportion.

There is a class of people who will reply to this that we have only to look into any elementary book on arithmetic, and there we shall find that sixty-nine and a half British miles make a degree;—the same gentlemen, amongst whom Mr. COBBETT has occasionally figured, whilst the humour was on him, together with many others as far surpassing him in rank as he does them in intellect, will be ready to declare that pounds, shillings, and pence are the only useful knowledge, and that tare and tret, and bills of parcels, are the fittest boundaries to limit the mathematical education of Englishmen. We all must recollect M. VOLTAIRE'S story of JEANNOT and COLIN. How the young JEANNOT suddenly became raised to the peerage from being a peasant, and how the father and mother of JEANNOT

* A practice common with the *Hindoos*.

† The Dutch boors at the Cape of Good Hope commonly estimate by this method. I am told the natives of the hills near *Assam* do the same.

discussed with his governor what he was to be taught, but that author must be left to speak for himself, for it is impossible to improve upon his delicate irony by any description.

“ Mais qu’ apprendra-t-il donc ? Car encore faut-il qu’il sache quelque chose ; ne pourroit-on pas lui montrer un peu de geographie ? A quoi cela lui servira-t-il ? repondit le gouverneur—quand Monsieur le Marquis ira dans ses terres, les postillons ne sauront ils pas les chemins ? ils ne l’ egareront certainement pas.”

We are all acquainted with what is called the precession of the equinoxes. The mean annual precession is the joint effect of the Sun and Moon, acting on the protuberant portion of matter about the equator, and is determined by finding how much any particular star has retrograded in right ascension, by a comparison of observations made by the older astronomers with those made in recent days.

But BRADLEY never would have been able to separate the inequalities which he detected only in heaps and parcels into the atoms of aberration, Solar and Lunar nutation, and inequality of precession, unless he had had an approximate value for the excess of matter at the equator, and it cannot be doubted for a moment that the nearer we approach to the real value of this astronomical datum, the more truly we shall be able to assign the amount of the effects which are produced by it.

Not to tarry too long at this part of the subject it will suffice to notice, that on account of the ellipticity of the earth’s meridians, the direction of gravity is not towards the centre, and that in the determination of Lunar parallaxes it is necessary to compute the angle, which the normal makes with the diameter drawn to any point on the surface, but this

angle being a function of the compression, a knowledge of the figure of the earth becomes here also an indispensable condition.

Enough has perhaps already been said to warrant the conclusion that this is one of the most important problems of astronomy in respect to practical utility, and he who would deny the expediency of prosecuting the researches necessary to its investigation, must be prepared to pronounce the same sentence of exclusion against astronomy as connected with navigation, against geography, against every other branch of science, or else to waive all claim to consistency. But the figure of the earth can only be known by a comparison of measures made in parts of the globe separated from each other by a considerable difference of latitude, such as two large arcs of the meridian or of longitude.

Hence then we arrive at the absolute necessity, as far as science is concerned, of establishing the exact relative value of the units which have been used as standards by the various nations who have engaged in what are called Geodetical operations, and first it is of all things requisite that we should begin by having some decided measure of our own.

For this purpose the Parliament of England selected the yard used by Mr. BIRD as the standard, and Captain KATER had the task assigned to him of comparing all the other measures, such as Sir GEO. SHUCKBURGH's, General ROY's, &c. with this; a detail of the experiments made for this purpose will be found in the Philosophical Transactions for 1821, as also the comparison of the English and French standard measures with each other.

The French at the time of the Revolution of 1791, when the rage for fraternizing and levelling was at its height, sought for some means of

establishing an universal system of weights and measures which should be common to all nations; but it would obviously be necessary to that end, that some unit, which nature afforded as a constant mark of reference, should be fixed upon as the basis of the system; now nature gives us many lovely flowers and beauteous plants, and a thousand and a thousand diversified shapes, but we can only cull from all her productions two units which are at all accessible and unchanging. These are the lengths of the pendulum in a given latitude, and of the meridional quadrant. The latter of these accordingly was selected, and great pains were taken by the French to deduce the exact distance from the Pole to the Equator by means of the comparison of an Arc extending from Formentera to Dunkirk, with the former measure of 1735, which I have above adverted to as having been undertaken under the government of Louis XV.

The ten millionth part of the meridional quadrant thus found, was taken as the future national standard unit of France, and called the *Mètre*.

The old French measure was the *toise* of 6 Paris feet, and the two iron bars of this denomination which went, one to the Polar circle, and the other to the Equator in 1735, had been rigorously compared with each other at the temperature of 13° of Reaumur; one of these, called the *toise de l'Academie* or *toise de Perou*, was still in good preservation, but that which went to the North had been rusted in consequence of having been shipwrecked in the gulph of Bothnia.

13° of Reaumur is equivalent to $16\frac{1}{4}$ of the scale of Celsius, or the centigrade, and to $61^{\circ}\frac{1}{4}$ of Fahrenheit. The English standard temperature is 62° of Fahrenheit. The temperature of the *mètre*, or module, is zero of the centigrade of Reaumur, and 32 of Fahrenheit.

We have still therefore much to abolish before we can arrive at any uniformity of measures, but in the present case it is an object to avoid confounding the subject of measurements made with a view to determine the figure of the earth, with those whose object is the establishing the length of the mètre. The latter seems to be now generally allowed to be a fanciful attempt, for what can it matter, whether we get our standard unit from nature or from art? Whether we first fix our foot or yard, and deduce the quadrant of the meridian in terms of it; or derive the length of our standard from the length of the second's pendulum, or from an aliquot part of the computed quadrant?

But to the determination of the figure of the earth, the relative values of the different national units which were employed, must be accurately known; moreover, as all operations undertaken for the purpose must depend on some base, which has been measured under different states of the thermometer, and perhaps under great alternations of heat and cold, it follows of course that the exact mean temperature must be known and corrected, unless some method can be devised of introducing into our apparatus the principle of its own compensation.

It is not an easy task, however, to ascertain the exact temperature of a rod of metal; thermometers may be placed near it, but they will only give the temperature of the surrounding air, which may differ very sensibly from the metallic bar.

The mode of measurement with a steel chain has hitherto prevailed in England and in India, but it is very objectionable principally on the following accounts.

1st. The impossibility of knowing its exact temperature and the consequent allowance to be made for expansion.

2nd. Of giving an equal degree of tension.

3rd. Of preserving the joints from the effects of oxydation and friction. Other reasons there are, but they might perhaps be remedied—those now detailed are insuperable.

It is not necessary to enter into the details of the various measurements made in France, or of that made by MAIRE and BOSCOVICH, commencing near the tomb of CECILIA METELLA, and the high way to Alba Longa, or the two operations of YAROUQUI and TARQUI in Peru.

Suffice it to say that in all such operations, the coincidence of a measured base of verification with one computed has never been free from the imputation of arising from a happy compensation of errors, whilst if there were a difference, no surprise was excited by it.

The apparatus before us is the invention of Colonel COLBY, of the Royal Engineers, and contains the principle of self-correction for increase of temperature.

* It consists of a series of bars arranged in pairs—each pair consisting of one bar of brass and one of iron. The pair thus formed is firmly clamped together in the middle by two cylindrical pieces of iron, so that no motion can take place towards the centre.

The length of each bar is 10 feet 1·4 inch, the breadth is 0·55 of an inch, and the depth 1·5 inch; at each of the extremities an aperture is worked out 0·9 of an inch high, and 1·1 inch longitudinally, extending

* The reader is referred to the accompanying plates containing plans, sections and elevations of the apparatus and its principal parts, for an explanation of this description.

through the whole breadth, and leaving 0·3 of an inch of the depth above and below; the parts which remain being perforated so as to admit a conical pivot to work in the two concentrically.

Now, if the two bars be placed parallel to each other and clamped together as abovementioned, and if a flat tongue of iron 0·25 of an inch thick, 1·1 broad, and 6·2 long, with two pairs of pivots, each pair forming an axis projecting perpendicularly to its plane, be applied horizontally to the apertures abovementioned, the distances between the centres of the two axes being 1·8 inch, it is plain that if one bar increase in length more than the other, one extremity of the tongue may, by means of these axes, revolve through a small arc round some point near the other extremity; and moreover, if there be such another tongue and apparatus at each end of the compound bar, both tongues will have a similar tendency, so that if the cause be the same of this increase in length, the one tongue will revolve through an arc just as great as the other.

In Colonel COLBY's system, one of the two bars is of brass, the other of iron. The tongue has one axis at 0·5 of an inch from one extremity, working into the aperture of the brass bar, and the other at 2·3 nearly working into that of the iron bar, whilst the rest of the tongue projects outwards.

The expansions of brass and iron are variously stated by different authors, but they are not far from the ratio of three to two.* Let us suppose them to be exactly so, then since 1·8 inch is the distance between the two axes, if double that distance, or 3·6 inch were set off from the

* Expansion of brass bar, 0000101850 }
 Ditto of iron bar, 0000069844 } Hasslar for 1°. of Fahrenheit.

centre of the axis, which works in the iron bar on the line produced through both axes, we ought to arrive at a point which would in no wise be affected by the forces arising from the jutting outward or shrinking inwards of the ends of brass and iron bars in consequence of increase of temperature.

Upon the principles of similar triangles, this point would form the vertex of a set of triangles whose bases are the relative increments of the brass and iron bars from heat, and as there would also be some nodal point on a tongue similarly situated at the other extremity of the compound bar, therefore the distance between these two nodal points would be constant, and in no wise liable to be affected by changes of temperature, provided such increase or diminution of temperature were suffered by each metallic bar at the same time and in equal intensity.

The difficulty then is to mark these neutral points and it is accomplished as follows. Two microscopes, with moveable wires, are fixed on solid stone pillars let into a wall of masonry, and when this has had time to dry and become perfectly consolidated, the moveable wires are adjusted over the two dots of an iron, or other standard of ten feet in length, at the temperature of 62° of Fahrenheit.

The bars are then heated in an oven as equably as possible up to the temperature of 180° or upwards, in that state they are taken out and placed under the mural microscopes, and a point on one tongue having been assumed, the corresponding point on the opposite tongue is sought for, which maintains an invariable distance from it during the process of cooling.

This operation is slow and tedious like all works of approximation, but it is particularly so because it appears from experiment that the brass

and iron bars do not cool equably, if their natural surfaces be exposed to the air. Hence it has been necessary to apply coatings of varnish so as to give surfaces which shall make them radiate alike, and as this varnish must be only applied partially, the quantity, which is just sufficient for the purpose, and no more, must be patiently ascertained by a series of repeated trials.

Strictly speaking, the distances from the neutral points on the tongue to the centres of the two points ought in every position to bear the same proportion to each other as the increments of the brass and iron bars do, but a very little consideration will suffice to shew that the increments of the tongue itself will not be sufficient to answer that condition; the error must however be one of the second order, and has hitherto been considered as rejectaneous, which it most probably is.

The compound bar thus formed, is placed upon two brass rollers which revolve each upon an axis fixed into a deal-box, whose length is sufficient to enclose the whole metallic apparatus, except the tongue which protrudes at one side, and is protected by a cylindrical cover of brass tube, part of which turns round and brings a circular aperture over the dot marking the neutral point. The box is of deal and painted white on the outside, it is lined with white cloth, and there is an inner box covered on both surfaces with white serge, so that a stratum of air may pass between the outer box and its interior lining.

At each end of this deal box there is a common brass sight which serves to lay the bar approximately; there is also a brass plate with screw holes, by means of which are fixed to the box the arms intended to support the microscopes.

There are seven sets of microscopes, each consisting of two common microscopes, and one telescopic microscope. The use of these is as follows. The two common microscopes are compensated by means of parallel bars of brass and iron in the same manner with the measuring apparatus, and the condition of compensation requires that, when each microscope is in focal distance in respect to the dot of the bar to which it is attached, the horizontal distance between the lines of collimation of the two microscopes shall always be the same quantity, which ought to be six inches of Parliamentary measure at the temperature of 62°

There are six of these compound bars which are aligned in succession by means of an instrument called a boning instrument, placed at a certain number of paces in the rear.

The first operation is to drive a set of pickets into the ground to support the tressels, two of which are required for each bar; this must be accomplished by measurement with a common chain or rope, the line of the pickets being traced with respect to the middle of the bars, and not that of the dots or microscopes.

The pickets being driven, one of the bars having a set of microscopes at each end, is brought into the alignment, by placing the telescopic microscope over the limit of the line to be measured.

Over the eye tube of this telescopic microscope a small brass upright called a director, is then raised, and the boning instrument, by means of this and the other limit, being now properly placed in alignments, the other end of the first bar is also placed right by means of its director.

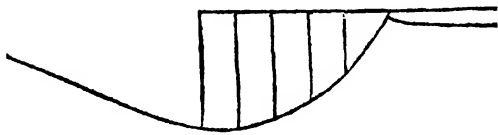
The second bar is now brought up to the first by placing the rear dot under the advanced microscope attached to the first bar, and raising or lowering it to focal distance. In the same manner the 3rd, 4th, 5th and 6th, when the series is terminated by fixing one of the triangular registers. After the length of the whole six bars has thus been taken off, the leading register is left standing and another set of bars is placed and measured off in the same manner.

For the better preservation of an equable temperature, the whole of the measurement with these bars is carried on under shelter; a certain number of tents of a suitable form being constructed on purpose, and especial care is taken to preserve the apparatus from the direct action of the sun's rays.

The adjustments of the sets of microscopes consist in placing the side telescope parallel to the plane which passes through the lines of collimation of the two microscopes, this is done as follows; direct by means of its sights, the six inch brass ruler to a mark on a piece of paper fixed at thirty or forty feet distance on a wall, and place over it the two microscopes with each of the dots under a wire, then direct the side telescope to the same paper, and mark the point it cuts. Now turn the set of microscopes half round in azimuth, so that the positions may be over the contrary dots to what they were before, and having turned the side telescope half over in altitude, mark the point on the wall which its wire cuts in this new position. If then the distance between each of these points, and the middle point be exactly equal, the line of collimation is quite parallel to the line running through the microscopes, otherwise it must be adjusted half by means of the screws, which affect the axis, and half by those which affect the line of collimation.

The measurement of every individual set of bars is taken horizontally, but it does not follow that the surface over which it is conducted need be horizontal; for each tressel stands upon three pickets driven into the

ground, and 1st, the heads of these pickets may be left more or less above the surface. 2nd. Upon the pickets a large triangular frame of three inches thick deal is placed, which in cases of emergency may be dispensed with or doubled. 3rd. The tressels may be of different heights, and do actually vary from thirty to six inches ; again, each bar is supported upon a brass fabric called a camel which rests upon the tressel, and is furnished with three levelling screws, and one in the middle for elevating, therefore ;



4th. The additional height given by the screws is three inches. These four means of adjustment may all be brought into play in descending or ascending a slope ; let us suppose the former case : then we should begin

with the lowest tressel, with the pickets as near the surface of the ground as possible, perhaps without any triangle over the heads of the pickets, and with the elevating and levelling screws of the camel quite drawn down whilst at the advanced end of the 6th bar, we should leave one inch or more of the pickets exposed, the highest tressel, supported on perhaps two triangles, would be used, and the elevating and levelling screws would be drawn out to their full extent.

The extreme difference of height which might thus be produced, would be about thirty inches in a set (or sixty-three feet,) but in this as in all other cases of human life, it is desirable to avoid having recurrence to extremes, and the *medio tutissimus* is the best guide.

I have said that each end of the frame of the bar rests on a brass support called a camel. These have rollers at top so that the motion of the whole longitudinally is easily effected with the hand, but that one of each pair of camels which supports the rear end of the bar, has a brass plate appended to it with a steel screw, whereby after the dot has, as nearly as can be, been brought into its proper position under the microscope, any

small alteration may be given to it longitudinally. This will be seen by a reference to the apparatus where the plate being fixed to the box by two brass screws, the long steel screws I have above mentioned, act in the same manner as a tangent screw on the limb of an instrument, and draw the whole bodily forward or thrust it backwards in a direction parallel to itself. There is also to each camel a large milled headed brass screw, which gives a differential motion laterally to each end of the bar.

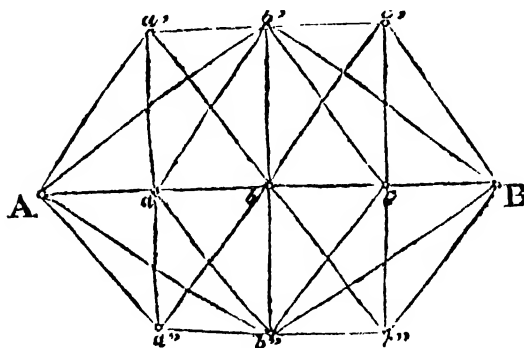
The registers which mark the limits of each set of bars in succession consist of a frame of cast iron, of a pyramidal shape, surmounted by a brass plate with a circular aperture of two inches in diameter. Through this aperture a tube is adapted to slide up and down, at the top of which is a circular head hollow, and perforated in the middle, so that an internal plate on which four screws act at right angles to each other may be moved differentially in a lateral or longitudinal direction; this moveable plate carries a very fine dot engraved on silver: some of these registers have the tube made to slide below the frame altogether, in which case the ground must be excavated from beneath it. Some are a mere triangular slab of cast iron with a moveable brass register in the middle, they are used at leaving off at night, and in cases where they are likely to be left standing for any time, being less liable to derangement than the more lofty ones. Each register rests upon a slab of stone sunk into the ground for the purpose.

The meaning of the sliding tubes is that the small dot on the moveable plate may be kept as nearly at the same distance from the telescopic micrometer as practicable, but in cases of ground which slopes greatly and always where this is not attainable, a provision is made for altering the focal length of this microscope by changing the object glass. A small box which accompanies contains twelve sets of object glasses for this particular purpose, varying from four to twelve inches, and there are four others which are adapted to a difference of height so great as twenty feet.

I have now given you a description of all this apparatus, which you will see is very complicated. It is only the second which has as yet been constructed, and has been made after the model of that used in the base line near Loch Foyle, in Ireland. I wish I had the particulars of that base line with me, because I am persuaded they would have been very interesting to you, but as that is not the case, I must content myself with doing the best I can by way of description from memory.

The different parts of the base were tried against each other somewhat in the way shewn in the margin.

The points A , and B , are the limits of the base in which a, b, c are intermediate points: a', b', c' are points chosen on the left, a'', b'', c'' on the right. The angles about A, a, b, c, B , are observed with an instrument as well as those at $a', a'', b', b'', c', c''$, so that taking any one intermediate



distance, that from a to b for instance, it will be determined in three different ways independent of each other, viz. 1st, actual measurement; 2nd, by the triangle a, a', b ; and 3rd, by the triangle a, a'', b . Some of the intermediate distances are tried by five, some by I think as much as

seven computations, and the greatest difference does not exceed 0.25 foot, or three inches in as many miles, in which are included the errors of centering the instrument wherewith the angles are observed.

The apparatus now before us was subjected to a full trial by order of the Hon'ble Court of Directors in April last, under my direction, in the spot called Lords' Cricket Ground in St. John's Wood road. I measured nine sets of bars with the assistance of Mr. BARROW, Mr. WESTERN, and the Astronomer at Madras, Mr. TAYLOR, a party of the R. E. I. Volunteers

having been lent for the occasion by the Chairman, and it is of importance to remark, that two of the Gentlemen of the Royal Engineers who had taken a prominent part in the measurement at Loch Foyle, Lieutenants DRUMMOND and MURPHY, were with me for two days, in order that no important step of the operation might be overlooked.

Having measured the nine sets of bars in question, I returned over the same ground, and on reaching the register from which I had originally started, the return measurement exceeded the prior one by $\frac{3}{40}$ th of an inch. Now $\frac{1}{40}$ th of an inch in five hundred and sixty-seven feet, would amount to 5·6 inches in eight miles, and to one hundred and forty-five inches in a section of the meridian of about three degrees.

The increments of degrees between the latitudes of 8° and 31° vary from 5·2 to 16·6 fathoms; if therefore we could be certain that this were the greatest quantity to be feared, there could be no doubt, philosophically considered, that the compensation bars would be quite adequate to the purpose for which they were designed, and that the superior accuracy attainable from them, would be commensurate with the greater toil entailed by their use, and the increased expence and complexity of their structure.

It is my opinion that the variation of $\frac{3}{40}$ th of an inch is rather more than need be apprehended, because the formation of Lords' Cricket Ground is a thick clay, which retains the moisture at the surface, and as for several days of the operation rain descended in great quantities, there was an alternation of dryness and humidity much more unfavourable than need be looked for in actual measurement on a great scale.

In fact the constant trampling of the feet of the soldiers and others who were occupied in the work, rendered such parts as were hollow perfect swamps, and ankle deep in mud and water, whilst the more elevated parts were hard and dry.

This is a matter of opinion in which every person must judge for himself; but if we refer to the bases measured by MAIRE and BOSCOVICH in Italy, by DELAMBRE and MECHAIN in France, by BOUGUER and DE LA CONDAMINE in Peru,* by ROY and MUDGE in England, by my predecessor and myself in India, we shall find no very insecure test of comparison to direct our judgment in forming an estimate of the superior accuracy likely to be attained by the new apparatus. I select these instances because I am not aware of any other operations in which two bases, verificatory of each other, have been measured. To take these then in order of their dates.

The first base was measured in the plain of Yarouqui from Carabouron to Oyambaro. It was performed with wooden rods called perches, prepared on the spot from a comparison with the iron toise. It was commenced on the 3d October, and ended on the 3d November, 1736. The ground was gone over by two parties independent of each other, and the mean of the two results was 6272.6559 toises = 7.60 miles in a horizontal direction. The base of Tarqui, which is in 3° 4' South of the Equator, was measured in the same manner in the month of August, 1739: it was carried on through swampy ground, and the wooden rods floated on the stagnant water, ("nous fûmes dispensés dans ce trajet de faire usage du niveau, les perches avec les quelles nous opérions flottaient sur l'eau.")

This base, reduced to the level of Carabouron, was 5258,949 toises, equal to 6.37 miles, and the same distance computed from the series of triangles was found to be 5260.03 toises,† shewing a variation of 1.081 toise

* The *Conquestadore* of 64 guns, and the *Incendio* of 50 guns, sailed from Cadiz Bay, May 26th, 1735. Bouguer, Godin, and De la Condamine, sailed from la Rochelle, in a Royal vessel 16th May 1735.

24th November embarked at Portabello, in company with the Spanish gentlemen; on the 10th June 1736, all the party assembled at Quito.

Dans un des intervalles de ce travail nous observâmes, le 19th Septembre au soir, l'Eclipse de la Lune. Tandis qu'on préparait les perches que devaient nous servir à mesurer la base.

† 5260 toises = 6 miles 3 furlongs.

between actual measurement and computation; but a length of 1·081 in 5260·03 amounts to 13 inches in a mile, or 104 inches in 8 miles, and nearly 38 fathoms in a section of 3 degrees. In the month of April, 1751, MM. MAIRE and BOSCOVICH, under the auspices and at the charge of Pope BENEDICT XIV, commenced the measurement of a base line from the tomb of CECILIA METELLA to within 3 miles of Alba. The operation was executed with wooden rods set off from the Roman palm, and was found to be 7901·14 passi Romani, equal to 7·312 English miles: the base of verification for this was measured at Rimini, and found to be 8034·67 passi, equal to 7·436 miles, whereas the latter deduced from the former in the table of triangles (Liv. II. Art. 20,) is only 8033·4, differing 1·27 passo, or 10 inches in a mile.

The length of the base of Perpignan is 6006·25 toises, it was commenced by MECHAIN and finished by DELAMBRE, in the month of Germinal, year 6 of the Republic, with the platina bars. It was connected with that of MELUN, which was executed by DELAMBRE, and is 6075·9 toises, the former deduced from the latter is 6006·09, exhibiting a difference of 0·16 of a toise, which is about 0·17 of an inch in a mile. The latter was completed in thirty-eight days: the expressions of the author are—“en travaillant depuis neuf heures du matin jusqu’au coucher du soleil nous n’ avons jamais pus parvenir à mesurer plus de 360 mètres* en un jour, c’est à dire, à placer plus de quatre vingt dix règles au bout l’une de l’autre.” The base of Perpignan occupied in all 48 days, and was terminated on the 1st supplemental day of the year 6. The author says in regard to this—“on voit donc que dans les circonstances les plus favorables on ne peut guère se flatter avec tous les soins et le scrupule que nous y apportons de mesurer une base de †12000 mètres en moins de cinquante jours.”

* 1181·1237 English feet.

† 39370·79 feet, or $7\frac{1}{2}$ miles nearly, which is at the rate of 797 or 800 feet per day.

The bars used by the French Geodists in measuring their bases are of a peculiar construction. They are of platina, two toises in length, 6 lines in breadth and about 1 line in thickness. Each of them is sheathed with a bar of copper within 6 inches of the extremity. The two plates of platina and copper are united at one end whilst the other is at liberty, and as the expansions of these two metals are nearly in the ratio of 1 to 2, it is evident that the unconnected end of the copper bar will advance or recede from that cause on the platina; the quantity being the difference of the increments or decrements due to the whole length of the bar. This then would be a thermometer of a most exquisite and delicate structure, provided the two metals radiated equally, and that the heat were equally diffused through the mass of each, but it is evident that such could never be the case unless the apparatus be sheltered from the direct action of the rays of the sun, and all other causes of inequality of temperature.

We come now to the measurements by General MUDGE with RAMSDEN's steel chain. In 1784 trials were made on Hounslow Heath, of a new chain, a set of deal rods, and a set of glass rods, on the 21st June of that year, a distance of 7.800 feet was measured and re-measured with the chains, and the return measurement differed from the 1st by $1\frac{1}{2}$ inch, that is, 1 inch per mile. On the morning of the 18th August, a space of 1000 feet was measured with the steel chain, and with a set of glass rods, and the difference after reduction for temperature was only .02 of an inch, a quantity incredibly small. The remainder of the Hounslow Heath base was measured with glass rods.

On Monday, 30th August, the measurement with the glass rods was completed, being after all reductions made, 27404,0137 feet at the level of the sea; so that the daily rate of progress was 2,108 feet. Here the soil is so level that the rods lay on the ground without support.

The base of Romney Marsh was measured with the steel chain, supported on coffers, it was begun on the 15th October, 1787, and ended 4th December, and was 28535.677 feet, and here we find introduced two of those cases of perplexity which I have alluded to before : viz.

Correction for contraction of the chain, Sub. 1.0667 feet.

Correction for wear of the chain, Add. 0.2735

I do not mean to say these are incorrect—all I mean is, that they are hypothetical, and as such are not as satisfactory to the common sense and good understanding of mankind as a measurement which is dependent on fact alone.

This base when deduced from that on Hounslow Heath by the triangulation, was 28533.3 feet, so that there is a difference between computation and actual measurement of 2.277 feet, which is at the rate of 5.06 inches in a mile.

In the Summer of 1791, the base on Hounslow Heath was re-measured with the steel chain in coffers, supported on pickets. The operation occupied 43 days, and was found after all reductions, to be 27404.3155 feet, or about .3018 of a foot greater than the former one—this is about .607 of an inch per mile, and the daily progress was 638 feet.

It is not necessary to go into a detail of all that has been executed with the steel chain in Great Britain, but it is some criterion for us to form a judgment respecting that apparatus, when a gentleman of Colonel COLBY's reputation and talent, who has been so active a participator in all connected with its application, comes forward as an active reformer, and by introducing the apparatus of which you now see the fac-simile, virtually pronounces his opinion as to the fallibility of that which he seeks to supercede.

As to the operations by my predecessor, they are all before you in the memoirs of this Society, excepting the last two bases, of which a detailed account is found in my printed book.

The first of these is the base of *Takal Khéra*, which was measured by Colonel LAMTON on the ground, between the 6th January and 25th January, 1822. It was 37912.56, &c. feet, and consequently the daily progress was 1896 feet nearly.

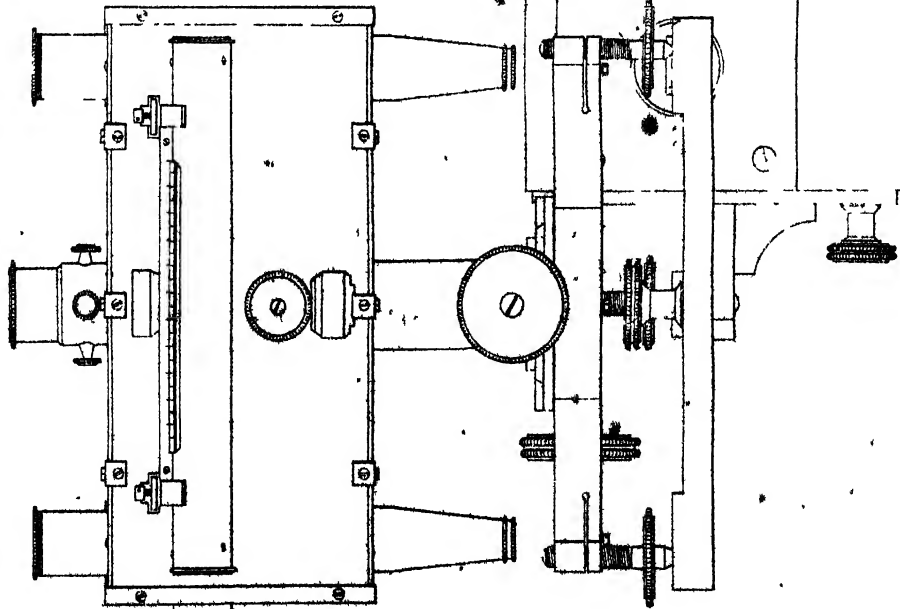
The base of *Seronj* was measured by me on coffers, and was 38411.9 feet, it was completed in 20 days, i. e. between 24th November and 13th December, 1824, the daily rate of progress was therefore 1920 feet.

The base of *Seronj* computed from the triangulation between it and *Takal Khéra* is 38412.16 feet, giving a difference of 0.26 feet in the whole length, or .4288 of an inch in a mile.

The *Beder* base, as will be seen on reference to the Transactions of this Society, was found from measurement to be 30806.176 feet, but the same base deduced from the series of triangles connecting it with *Takal Khéra*, is only 30799.61, giving a difference of 6.57 feet nearly, or 13.516 inches per mile.

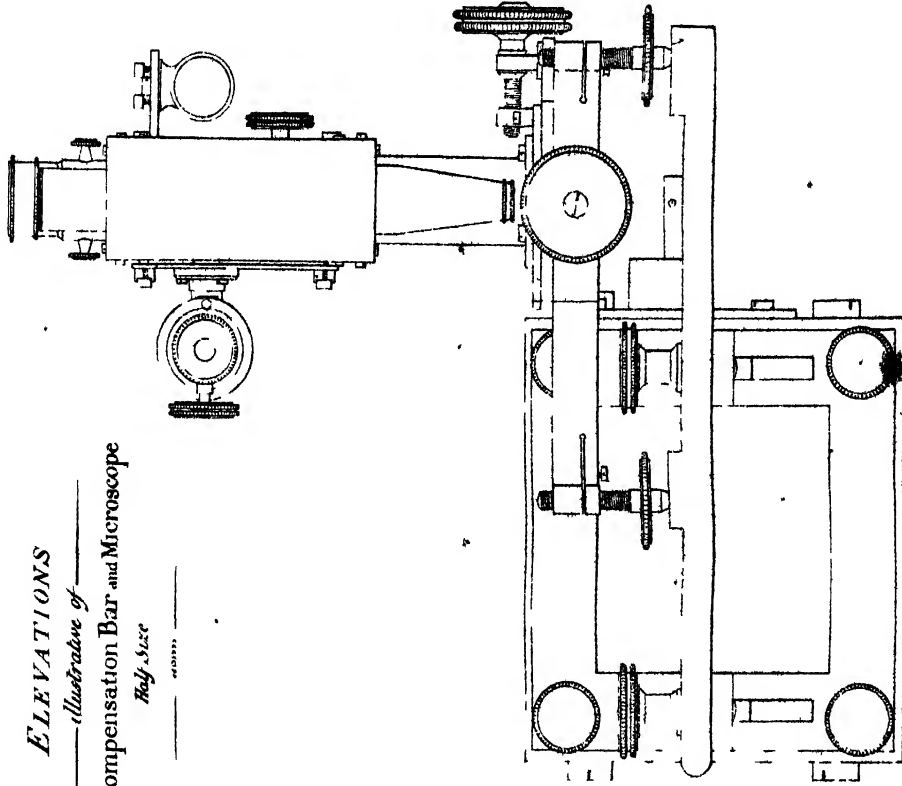
Thus then, it would seem, that the chain though generally correct, is not of that trust-worthy nature that can induce an entire confidence in the results it produces. A happy combination of errors may perhaps, and generally will make them annihilate each other, but there is an uncertainty attached to the reliance on such a contingency, which is any thing but satisfactory in cases where the exact sciences are concerned.

Front Elevation



ELEVATIONS
—Illustrative of—
the Compensation Bar and Microscope
Half Size

End Elevation



XIII.

EXPERIMENTS

ON THE

STRENGTH AND ELASTICITY

OF

INDIAN WOODS.

By CAPTAIN H. C. BAKER,

Bengal Artillery,

AGENT FOR IRON SUSPENSION BRIDGES, &c

THE experiments detailed in the following Table were made on different occasions, to determine the strength of various specimens of Wood supplied to me by the Honorable Company's Timber Agents, and by private individuals, who were interested in the subject, and who had opportunities of obtaining foreign Woods in their visits to the Tennasserim Coast, Arracan—the Morung forests, Orissa, &c. A short account of some of my original experiments, was published in the *Gleanings in Science*, vol. I, pages 123 and 231; but as many of the Woods then submitted to trial, were hardly in a seasoned state, I have included in the present Table only the later experiments upon them when they were perfectly seasoned, and when therefore more dependence could be placed on the results.

I regret that the Notes furnished with the Specimens were, in most cases, insufficient to enable me to describe at large the qualities of the several kinds of Timber, or the purposes to which they are applied in the countries where they flourish: the native names too, are, in many instances, of doubtful orthography, resting upon the vague pronunciation of the people of the spot, and taken down by mere sound of ear. In most instances, however, with the kind assistance of the Revd. Dr. CAREY, and Mr. POTTER, for the Woods of Bengal and the East, and of Drs. ROYLE and FALCONER, for those of Upper India, I have been able to assign the Botanical names of the trees.

The numbers in the first column refer to the Specimens lodged with the Society. The results given are the means of about four experiments on each kind of wood. The term C, or direct cohesive strength in lbs. avoirdupois in the square inch, in the last column, is experimentally found by tearing asunder about an equal number of specimens, turned according to the method described in BARLOW'S Treatise on the "Strength and Stress of Materials."

The Specimens, except when otherwise stated, were six feet long, two inches square: the distance of the supports five and a half feet.

CALCUTTA, }
November 1, 1832. }

Mean results of a course of Experiments on the elasticity, and on the transverse and direct cohesive strength of various Indian Woods, 1830.

Corresponding Number of Box Specimen.	NAME.		Specific Gravity.	Greatest weight and deflection whilst elasticity remained.		Ultimate deflection in inches.	MEAN VALUES OF				REMARKS.
	LOCAL.	BOTANICAL.		Weight, lbs.	Deflection, inches.		U from the formula $U = \frac{l^2}{d\Delta}$	E from the formula $E = \frac{ad^3}{l^2}$	S from the formula $S = \frac{WF}{4ad}$	C Direct cohesive strength in lbs. per sq. inch.	
37	Pussoor,	Xylocarpus granatum,	837	150	·698	478	981	5004220	1075	6588	Soodurbuns 1829.
37	Ditto,	Ditto,	632	200	·869	705	700	5368929	1586	6588	
38	Chittagau Oak,	Quercus castanicaarpa ?	962	500	1·13	1168	648	10322120	2628	23944	Soodurbuns, received 1828-9, from Captain Murray, Executive Officer, Public Works at Bursial.
41	Chumalis,	Artocarpus chaplasha,	581	200	1·085	575	785	4241910	1294	10429	
43	Choangree,	Artocarpus chaplasha,	562	200	·971	616	771	4743900	1386	8470	
42	Hurina,	Acacia heterophylla,	994	500	1·6	1352	551	7290000	3042	32472	
39	Gulgulia,	Amyris agallocha,	714	200	·86	566	864	5425116	1273	9219	
40	Telsur,	Shorea talura ?	769	300	1·0	947	490	6998400	2131	10994	
44	Koorye,	Acacia marginata,	839	300	·981	778	760	7133944	1750	12506	Soodurbuns, received 1828-9, from Captain Murray, Executive Officer, Public Works at Bursial.
47	Sassafras,	Cryptocarya glaucescens ? ..	557	200	·91	626	630	5127032	1658	10778	
46	Red or dye wood,										Tenasserim Coast, imported 1827-28, by the <i>Ernaud</i> , well seasoned.
	Mergui,	Melanorrhoea usitata,	823	450	1·3	993	760	8073076	2234	18562	
54	Pyeng-ma,	Lagerstromia,	734	350	1·12	1015	530	7284410	2284	22513	
55	Kanza kurro, ..	Meliacea,	703	350	1·0	918	740	8164800	2065	13096	
57	Anaun,	Hopea odorata,	1048	300	·768	932	878	9112500	2097	14008	
52	Thengan,		707	300	·993	932	648	7047734	2097	12770	
56	Kaddoot,		751	350	1·0	985	680	8164800	2216	15986	Chittagau, 1830.
53	Thaban,		772	450	1·22	1034	550	8604590	2326	19588	
41	Chumaleez,	Artocarpus chaplasha,	409	150	·806	443	1039	4341439	997	7447	
245	Much,	Pterospermum acerifolium, ..	672	300	1·0	876	450	6998400	1971	18818	
238	Lohanae pooya, ..		506	150	·73	478	1037	4793424	1075	9884	
246	Badna,	Quercus castanicaarpa,	1028	500	1·16	1084	490	10055170	2439	20819	

Corresponding Num- ber of Box Specimen.	NAME.		Specific Gravity.	Greatest weight and deflection whilst elasticity remained.		Ultimate deflection in inches.	MEAN VALUES OF				REMARKS.
	LOCAL.	BOTANICAL.		Weight, lbs.	Deflection, inches.		U from the formula $U = \frac{f}{d \Delta}$	E from the formula $E = \frac{P W}{a d^2}$	S from the formula $S = \frac{P W}{4 a d^2}$	C Direct strength in lbs. per sq. inch.	
242	Chugrasee,	Swietenia chuckrassa, ...	8.59	150	.718	.27	960	4873546	1048	7784	Chittagong, 1830.
239	Petras, or Pitraz	...	665	200	.68	.35	740	6861176	1447	9246	
241	Chudool,	Hybiscus?	331	100	.81	.35	740	2880000	763	4488	Morning Forests, 1828.
232	Dood Peechul...	Trewia nudiflora, ...	522	150	.706	.32	810	4956373	1136	9079	
231	Huretukce,	Terminalia chebula, ...	840	200	.9	.48	540	5184000	1723	14476	
240	Goodgootea,	Amyris agallocha, ...	862	200	.825	.45	576	5653272	1712	13938	
235	Hurena Aswara,	Acacia heterophylla, ...	1035	200	.86	.31	836	5425116	1354	12382	
237	Loo-eca, .....	...	671	150	.618	.315	820	5710983	1215	13398
243	Kamdeb, ... ..	...	615	200	.86	.46	560	5425116	1766	8134
233	Gurjun,	Dipterocarpus incanus,	823	300	.8875	.495	523	7998171	2018	.....
236	Jam,	Calyptranthes jambulana, ...	825	200	.925	.43	602	5043889	1433	12440	
244	Koorye,	Mimosa marginata, ...	963	200	1.025	.375	708	6292217	1553	11795	
234	Oream,	Mangifera sylvatica, ...	639	150	.631	.37	700	6337700	1625	7550	Chittagong, 1830.
247	Amrooz,	Pyrus communis, ...	564	150	1.14	.46	560	3069473	1039	8118	
249	Babul, ... ..	...	416	100	.65	.47	550	3588923	976	6087
84	Paunjur, ... ..	...	994	500	1.175	.46	560	9926808	2720	18778
86	Dhauba, .....	...	949	500	1.194	.375	691	9768811	2833	22413
79	Koosum,	Carthamus tinctorius? ...	1167	450	1.875	.29	890	5598720	2997	12094	
83	Assaun, or Asin,	Pentaptera tomentosa, ...	862	450	1.194	.495	523	8791959	2333	21919	
80	Kussooma, ... ..	...	949	300	1.05	.365	710	6605619	1676	13919
85	Jummooa,	Sizygam lateriflorum, ...	948	300	1.064	.4175	620	6397074	1872	11467	
87	Kurmine, Kur- mah,	Phoenix dactylifera, ...	655	200	.781	.36	720	6053905	1588	14941	
81	Paunder,	Sp. of Bignonia, ...	721	200	.7	.575	450	6665142	2216	13022	

86	Seriss,	Acacia Senisha,	792	300	-969	926	36	720	72922291	2083	9382
87	Bhaunjee,		797	200	-71	764	36	720	6371267	1723	12142
88	Dhoree,	Grisea-tomentosa,	713	200	-65	661	27	680	7177846	1487	12882
89	Tekolee,		793	300	1-025	989	5-075	510	6837707	2225	18005
206	Abnoos,	Diospyros melanoxylon,	893	300	-85	741	4 0	648	8233417	1667	12593
65	Sissoo,	Dalbergia sisu,	1032	450	1-325	1133	5-25	404	7922716	2548	18500
233	Mahole,	Bauhinia racemosa,	1002	150	-56	619	3 8	680	6248571	1397	14437
258	Assun,	Pentaptera tomentosa,	1009	300	1 06	909	4 8	540	6602261	2045	22423
259	Teneea,		1047	300	-9	840	3-275	790	7776000	1890	12026
256	Cussee,		1040	200	-775	702	3 9	660	6020129	1579	11158
254	Nember,		965	150	-75	478	2-075	680	4665600	1075	9683
255	Tentara,		850	200	-7125	687	2-075	960	6548210	1546	15501
252	Cungra,	Webera corymbosa,	947	200	-725	702	2 75	942	6435310	1579	13718
250	Saul,	Shorea robusta,	894	450	1 2	1018	4 3	602	8748000	2290	16351
263	Mussoo,		884	450	1 66	1 14	9 25	250	6323855	2281	20558
264	Rajmooc,		825	200	-8875	658	3 875	660	5237014	1480	9804
64	Peersaul,	Buchananian latifolia,	795	300	1 875	916	4 4	580	3732480	2061	12906
260	Bundun,		855	300	-925	952	4 8	660	7565837	2142	23504
257	Patmooc, ...	Trewia nudiflora,	732	200	-76	726	3 525	900	6138947	1636	
261	Croom,	Phoenix dactylifera,	730	300	1-2125	799	4 7	680	5771871	1798	17231
267	Koochila,	Strychnos nux vomica,	971	200	-75	702	3 45	920	6220800	1579	13627
265	Sujna puttrea, ..		925	200	-725	629	2 65	981	6435310	1415	11000
262	Teak,	Tectona grandis,	729	200	-7	643	2 35	1103	6665142	1447	21937
91	Gamar,	Gmelina Arborea,	645	150	-69	609	3 9	820	5071304	1370	11181
	Patmooc,	Trewia nudiflora,	459	100	-55	458	3 85	830	4241454	1030	5434
231	Mahanecm,	Qu. Melia semper virens, ..	430	100	-55	396	2 75	942	4241454	891	5189
268	Benta,	Ricinus communis,	899	200	-725	897	3 85	830	6435310	2018	9763
207	Mahogany,	Swietenia mahogani,	673	200	-90	786	4 76	670	5184000	1768	11185...
73	Satin wood,	" chloroxylon,	1020	300	1 01	1068	5 25	600	6929108	2403	10866
269	Koosum,	Carthamus tinctorius,	930	450	-8375	1227	2 65	821	6458860	2531	11612
266	Bhero,	Zizyphus jujuba,	846	500	1 17	1176	3 5	740	9696230	2646	13016
271	Peetara,	Trewia nudiflora,	528	200	-975	518	3 975	800	4785230	1165	10970...

Orissa

1830. } felled
1839. }

Morung forests,
1828.

Thia the "Kur-
rat on Trinoh,
K. of
Nahpore.

Dhokanal, forest Orissa, felled 1829.

Honduras.
Purchased in Cal-
cutta, supposed
from Buthan
Dhokanal forest,
Orissa, 1829. Re-
ceived 1830.
Arracan. Received
1830, June.

Corresponding Num- ber of Box Specimen.	NAME.		Specific Gravity.	Greatest weight and deflection whilst elasticity remained.		Breaking weight in lbs.	Ultimate deflection inches.	MEAN VALUES OF				REMARKS.
	LOCAL.	BOTANICAL.		Weight, lbs.	Deflection, inches.			U from the formula $U = \frac{P}{d \Delta}$	E from the formula $E = \frac{PW}{ad \cdot \delta}$	S from the formula $S = \frac{PW}{4ad \cdot \delta}$	C Direct cohesive strength in lbs. per sq. inch.	
229	Burroona,	Capparis-trifoliata,	414	150	·8125	495	3·9	820	4665600	1109	10761	Arracan. Re- ceived 1880, June.
273	Kaddumba,	Nauclea cadumba,	403	150	·8625	489	4·025	790	3782918	1100	7969	
272	Chasteen,	Alstonia?	448	150	·725	420	2·4	1080	4826482	945	4668	
226	Jumoreea, ....	.....	796	200	·79	831	5·45	587	5813831	1870	18769
210	Basualeea,	Lagerstromia grandiflora,	471	100	·65	412	3·25	980	3388923	927	7824	
228	Sunnusuleea, ..	Synplocos spicata?	431	100	·5625	432	3·425	980	4147200	1017	9285	
196	Gouda-aswara, ..	Vitex?	726	150	·65	761	3·9	820	5383384	1712	19182	
274	Chakhoa,	Cassia obtusifolia,	376	100	·81	398	5·6	571	2880000	895	5298	
200	Kesuma, .. ....	.....	721	200	·84	778	5·8	551	5554285	1750	19922
227	Brenjooree,	Cassia Sumatrana,	629	150	·99	479	3·45	927	3534545	1078	12496	
230	Bhadee,	Garuga pinnata,	529	100	·76	410	4·15	771	3069473	922	6476	

Note.—It has been thought better to leave the names as written in the manuscript, since, in many cases, the orthography according to the system followed in the Researches could not be introduced, for want of reference to the names in the native character. P.

XIV.

DESCRIPTION OF THE WILD DOG OF THE HIMALAYA.

By B. H. HODGSON, Esq.

KATHMANDU

CANIS PRIMÆVUS. (Mihi.)

The *Búánsú* of the Nipalese. *Habitat*, The whole of the Sub-Himálayan ranges from the Satlej on the West to the Brahmapútr on the East.

SPECIFIC CHARACTER.

Wild Dog, with six molars only in the lower jaw, double coat, hairy-soled feet, large erect ears, and very bushy straight tail, of medial length, deep rusty colour above, yellowish below.

THE Dog, man's first and best ally among the brutes, cleaving to us from the beginning, accompanying us in all our settlements in every climate of the habitable globe, and submitting his fine plastic form and faculties to be moulded at will by our wants and our caprices, has been so thoroughly changed by influences very similar to those which have operated upon ourselves, that his original, like our's, has been supposed to have now become inscrutable.

The Greyhound and the Bull Dog, like the Georgian and the Negro, are, it is supposed, in their respective kinds, specifically the same; and the test of this specific identity is that the progeny is prolific. But the application of this test to the Canine race having been found to identify the Wolf, the Jackal, and the Fox, with the Dog, the Zoologists of the last age, who unhesitatingly admitted the test, and who had no knowledge of a Wild Dog, properly so called, assumed, of necessity, some of them, the Wolf, others, the Jackal, and others again, the Fox, as the primordial type of the Canine race. The superior Zoological Science of the present age has perchance suggested some little doubts as to the soundness of the test of species above named; and, certainly, if we pursue this hypothesis into all its known consequences, we shall see room for hesitation. Although, therefore, anatomical investigation has failed to discover any material difference of organization or habit between the Wolf, Jackal, Fox and Dog, and although these several races will breed together, yet the present masters of the subject of Canine genealogy (M. F. CUVIER and M. DESMAREST) notwithstanding their continued want of an unquestionable Wild Dog, have refused to supply the deficiency of an original type by adopting as such the Wolf, the Jackal, or the Fox.

By M. F. CUVIER whose arrangement of the CANINÆ, has been ratified by all the first Zoologists in Europe,—the Dogs are disposed according to their approximation to the primitive type so far as that type was discoverable in the wildest race known then to exist, and of which there were specimens accessible to him. The race in question is the *Dingo* of Australia.

But, as the *Dingo* is, unquestionably, at least half reclaimed, I presume that a careful account of an entirely wild species of Dog, will be very acceptable to all who take an interest in the subject. And which of

us but must regard with interest the portrait of the primitive Dog, either from affection for that devoted friend and follower of human kind, or, from the light which the inquiry is calculated to throw upon the nature and limits of the distinction of species.

The *Búánsú*, or Wild Dog of the *Nipalese*, inhabits that part of these mountains which is equidistant from the snows and the plains, or in other words the middle region of *Nepal*. But he frequently wanders into the southern division, and, sometimes, into the northern. His limits, east and west, are, as I know, the *Kali* and *Tista*; and, as I am informed upon good authority, the *Sallej* and the *Brahmapútr*. Wild Dogs, probably not materially differing from those of *Nepal*, are found, likewise, in the *Vindhya*, the *Ghâts*, the *Nílگیرis*, the *Kasya Hills*, and finally, in the chain extending brokenly, from *Mirzapur*, through south *Behar* and *Orissa* to the *Coromandel Coast*.

Nor do *Ceylon* and the Eastern Islands want their Wild Dogs; and it is not therefore without surprise that I find the first Zoologists in Europe, whilst expressly treating of the Dog, as he was prior to all cultivation, instancing the more than half domesticated races of Australia and of North America. But the fact is that the Wild Dog of the East (where alone he seems now to exist) is so extremely wild as to be really seen, more rarely killed, and still seldomer procured alive; and that Britons in India have too little leisure to record with the requisite accuracy of detail for scientific purposes their casual observations, whilst sporting, of new and remarkable animals. I have myself been acquainted with the existence and general character of the Wild Dog of *Nepal*, for a long time past, and some years ago I sent to M. DUVAUCEL, two very fine specimens alive; which, however, probably met the fate too often attending presents of this sort.

But having since obtained many individuals, alive, some of which lived in confinement many months and even produced young, having been enccinte when they reached me, I considered it my duty to keep memorandums of such traits of character and manners as I was enabled to observe; and, as I see no prospect of the task falling into abler hands, I shall now record the substance of those memorandums, embodying them in such a description of the essential characters, aspect and habits of this most rare animal, as my small conversancy with the science will permit me to give.

To my description, I shall add drawings of the *Búánsú* and of his skull, together with (for the sake of comparison), others of the Jackal and Fox, and of their skulls. These drawings are upon an uniform scale, reduced with the Camera, from others of the natural size; and, in order to be more precise, I shall in my description of the *Búánsú* follow the principle upon which the sketches have been executed; that is, I shall endeavour to illustrate my subject by constant reference to the Jackal, and occasional reference to the Fox—animals which are, or ought to be, sufficiently well known.

Of all the wild animals that I know of similar size and habits, the *Búánsú*, which is large, gregarious, and noisy in his huntings, is the most difficult to be met with. He tenants solely the deepest and most solitary forests of this woody and little peopled region. The woods which cover the mountains environing the valley of *Nepal* proper afford shelter to numbers of Jackals as of other wild animals; but the *Búánsú* never was known to enter them, or, to approach so near to a populous district. This prototype of the most familiar of all quadrupeds with man is, in the perfectly wild state, the most shy of his society. I never beheld the *Búánsú* myself in the state of freedom, and therefore what I am about to say of

his manners in that state must rest upon the authority of others—highly respectable natives who spoke to what they personally knew.

The Wild Dog preys by night and by day, but chiefly by day. Six, eight, or ten unite to hunt down their victim, maintaining the chase by their powers of smell rather than by the eye. They usually overcome their quarry by dint of force and perseverance, though they sometimes effect their object by mixing stratagem with direct violence. Their urine is peculiarly acrid: and they are said to sprinkle it over the low bushes amongst which their destined victim will probably move; and then, in secret, to watch the result. If the stratagem succeed they rush out upon the devoted animal, whilst half blinded by the urine, and destroyed it before it has recovered that clearness of vision which could best have enabled it to flee or defend itself.

This trick the *Búánsús* usually play off upon the animals whose speed or strength might otherwise fail them, such as the buffaloe, wild and tame, and certain large deer and antelopes. Other animals they fairly hunt down, or furiously assail and kill by mere violence. In hunting they bark like hounds; but their barking is in such a voice as no language can express. It is utterly unlike the fine voice of our cultivated breeds; and almost as unlike to the peculiar strains of the jackal and of the fox. The *Búánsú* does not burrow like the wolf and fox: but reposes and breeds in the recesses, and natural cavities of rocks, in the manner of the jackal of *Nepal*. These peculiarities of domicile are probably in a great degree the consequences of the respective habitats of the animals in open plains or mountain fastnesses: and they doubtless change them when constrained to change their location. There is scarcely a wild animal, however large or formidable, which the Wild Dogs will not sometimes attack and destroy; and tame buffaloes and cows, when grazing in very solitary districts,

sometimes fall a sacrifice to their ravenous appetite. Human beings they are never known to attack; and indeed they seem to be actuated by a very peculiar degree of dread of man. Those which I kept in confinement when their den was approached rushed into the remotest corner of it, huddled one upon another with their heads concealed as much as possible. I never dared to lay hands on them, but if poked with a stick they would retreat from it as long as they could, and then crush themselves into a corner, growling low, and sometimes, but rarely, seizing the stick and biting it with vehemence. After ten months' confinement, they were as wild and shy as the first hour I got them. Their eyes emitted a strong light in the dark; and their bodies had the peculiar fetid odour of the Fox and Jackal in all its rankness. They were very silent, never uttering an audible sound save when fed, at which time they would snarl in a subdued tone at each other, but never fight: nor did they on any occasion show any signs of quarrelsomeness or pugnacity,—I turned a female jackal amongst them, which they admitted to share their den without the least sign of dissatisfaction. She lived amongst them many months, but never showed any symptoms of breeding; nor indeed did any of the Dogs amongst themselves, though there were males and females. Three of the latter, at different times, came to me enciente; and, in the early part of February, produced from two to four whelps; in no instance more. The mothers licked them clean, and then utterly deserted them, but in no instance devoured them. One of the finest males I had broke loose, and, leaping a six-feet wall, attempted to make off; but being instantly apprised of the fact, I gave him chase with greyhounds and horse. I shall mention his peculiar action by and bye, and meanwhile shall only observe that, after a run of a mile, we suddenly came up with him and found him quite dead! The violent exertion after long confinement, proved too much for him; he broke his heart. All my specimens refused dressed meat, and were fed with raw buffaloe beef. Besides the grown animals, I procured one young one, in March, about

a month old. I kept it in the kennel with the other dogs, where it lived for four months, and then died of diarrhœa. This little creature, too refused every sort of food but raw meat. As it grew up, it was suffered to go at large, and never attempted to run away. It was very frolicsome, and would play, for want of a mate, with its own tail—for, notwithstanding all its efforts to induce the other dogs to romp with it, one pup only out of several would have anything to say to it, and the grown dogs all avoided it. Its voice when extremely excited was a squeak. At all other times it was silent, and it never made the least approach to a bark, properly so called. When angered, it showed its teeth and applied its tail close to the buttocks, in the manner of the domestic dog. When gratified by caresses, it threw itself on its back, pawed the caresser's feet, and uttered its peculiar squeaking notes. It distinguished the dogs of its own kennel from others, as well as its keeper from strangers, and in its whole conduct manifested to the full as much intelligence as any of my Sporting Dogs of its age. But it was a shy shrinking creature, and rather unmanageable on that account, and it would not endure being tied up. When this young animal reached me, it had scarcely any taint of the villainous odour proper to its race—the consequence of youth merely—for as it grew up the odour increased more and more. The whelps, when born, have it not in the slightest degree, males and females, when adult, are equally infected with it.

The *Búánsú* is, in size, midway between the wolf and the jackal, being two and a half feet long from the tip of the nose to the insertion of the tail; and twenty-one inches in average height. It is a slouching, uncompact, long, lank, animal, with all the marks of uncultivation about it—best assimilated in its general aspect to the jackal, but with a something inexpressibly, but genuinely, canine in its physiognomy. It has a broad flat head, and sharp visage: large erect ears: a chest nor broad nor deep; a shallow compressed barrel somewhat strained at the

loins ; long, heavy limbs ; broad, spreading, feet ; and a very bushy tail of moderate length, straight, and carried low. Its colour is deep rusty red above, yellowish below. It stands rather lower before than behind, with the neck in the line of the body, the head unelevated, and the nose pointed almost directly forwards ; the fore limbs, straightened ; the hind, stooping ; the back, inclined to arch, especially over the croup ; and the tail pendulous. In action the tail is slightly raised, but never so high as the horizontal line. Though the *Búánsú* be not deficient in speed or power of leaping, yet his motions all seem to be heavy, owing to their measured uniformity. He runs in a lobbing long canter, is unapt at the double, and, upon the whole, is somewhat less agile and speedy than the jackal—very much so than the fox. In general aspect there can be no comparison instituted between the *Búánsú* and the fox : but one may illustrate him by such a comparison with the jackal. To a rather more full opened eye, better placed in the head, and provided with something like a brow, the *Búánsú* chiefly owes his less sinister and more dog-like expression of countenance—the effect being aided by a rather better forehead, and less elongated and sharpened face. The Wild Dog's ears are twice as large as the jackal's ; his limbs considerably longer ; and his feet larger and more spread out, not to mention the great tufts of floccy hair with which their soles are provided, and of which we find hardly a trace in the jackal's feet.

The fur or external covering of the *Búánsú* consists of wavy wool, and straight harsh hair—in Summer in nearly equal proportions—in Winter, two parts of wool to one of hair. The hair is, on the neck, 3 inches long ; on the back, $2\frac{1}{2}$ to $2\frac{3}{4}$ inches ; and on the tail $4\frac{1}{2}$ to 5 inches. On the face, ears, forehead, upper surface of the head, and legs, the hair is very short, closely applied to the skin and unmixed with wool. On the body in general it is longish, smoothly directed backwards, and rather loosely applied to the skin, by reason of the wool insinuating itself

between the interstices of the hair and ascending with it for two-thirds of its length. But on the neck and cheeks you have none of the more or less composed set of the hair elsewhere, those parts being shaggily dressed in hair, the set of which is irregular, but mostly outwards or porrect from the skin. The cheeks have in consequence the appearance of being whiskered; and the apparent volume of the head is thus greatly increased. The hams posteriorly are somewhat feathered; the belly and legs scarcely so. The hair generally has a four-fold annulation of colour, from the base thus; whitish, black, deep rusty, black—the first ring being very small—the second and third large and equal—the fourth, small. The visible effect of this distribution and proportion of the colours, aided by the reddish blue of the wool, is, that the animal appears to be of a full ferruginous red; the two basal rings being invisible and the terminal one scarcely noticeable from its smallness—not to mention that it exists only on the dorsal surface, and not on the sides; nor, of course, below, where the colour of the animal is yellowish and no rings are found. The tail towards its base is ringed with pale rusty and blackish—towards its tip the hairs are almost or wholly blackish.

The jackal, which is furred in a very similar manner to the *Búánsú*, has his hair likewise ringed in the same way. But owing to the largeness of the terminal black ring, and to the very pale tinge of the penultimate red one, the general effect is very different. The jackal in consequence appears to be pepper and salt coloured with a tawny tinge; whilst, as already observed, the *Búánsú* shows deep rusty red. Let us now recapitulate the colours of the animal in the ordinary mode of description. Whole superior surface, with outsides of ears and of limbs as far as the wrists and hocks, deep rusty red, sprinkled with black on the back: whole inferior surface, with insides of the ears and limbs, and also the lips and jaws and feet, yellowish: chin darkened and reddish: bridge of the nose brownish: terminal half and more of the tail, blackish. Bristles of the lips, cheeks and

chin, reddish: those above the eyes, black: irides, red brown: naked skin of the nose and lips and the nails, black: palate and tongue fleshy white, with some stains on the former near the muzzle. Such is the male. The female is rather paler and has hardly a sensible sprinkling of black-tipped hairs on her back. She is rather smaller than the male, has her cheeks less tufted, her tail less bushy. She has connexion with the male once a year only, in the months of November and December, and produces her young, after (it is presumed—and, for the most part, determined by facts) the usual period of gestation, in January and February. Though she has as many as thirteen teats, it would seem that she brings forth no more than from two to four whelps; which are born blind, and covered with short soft fur of a deep brown colour without any tinge of red. The red hue, however, soon begins to develope itself, but does not entirely obliterate the brown till after the milk teeth have been cast. In breeding only once a year, and in producing a small number of pups, the Wild Dog agrees with the *Páriár*, or Chien de rue of India, and with the jackal: whence it is probable that the double brood and numerous offspring at a birth characterising our sporting dogs, are sheer consequences of their being pampered and highly and regularly fed.* I shall conclude this account of the *Búánsú* with a separate notice of each of his principal members and

* One of the fancied distinctions between *Canis* and *Lupus*, upon which BUFFON founded his assertion of specific difference in the two races, was, that the Wolf breeds only once a year, the Dog twice. But so purely is the double brood of the domestic Dog the consequence of high and regular feeding that the hard-faring *Paríar*, reclaimed though he be, essentially, yet breeds but once a year. Facts like this ought to make one chary of creating specific differences founded on the œconomy of procreation, where the objects of comparison are not in a purely wild state.

Domestic Dogs in general have no more than ten teats—and in this point the *Paríar* agrees with them. On the other hand, the *Búánsú* has as many as thirteen teats, a fact which he who is inclined to separate the *Búánsú* from *Canis* will doubtless insist on; see in the sequel, the remarks on the dentition of the *Búánsú*. But what do I mean by thirteen, that is by an *odd number* of teats? I mean simply that I have counted them; and that, proceeding on the same principle of using my own eyes instead of the spectacles of books, I have found several birds with an odd number of feathers in the tail, independently of accidents. Yet I never found a hint of the kind in any work on Natural History!

organs. But having already described with sufficient particularity the body and legs of the *Búánsú*, I shall confine myself here to the feet, tail and head.

The feet are large and somewhat spread, pentadactylous before, four-toed behind. The fifth toe before is short and elevated, as usual; and at the back of the wrists is the ordinary callosity. The nails are strong and truncated by attrition; and the soles of the feet are provided with the common number of balls or rests. These balls are made, as usual; but every part of the inferior surfaces of the feet beyond the strict confines of the balls themselves, together with the interstices of the digits, is furnished with long, soft, loose, hair, projecting beyond the feet in every direction, and giving them an appearance of extreme size. I know no domesticated dog, but the Kabul greyhound which is similarly provided: and as both live in mountainous countries where their feet are apt to be cut by sharp edged stones and rocks, the purpose of these socks or sandals (so to speak) is probably to protect the feet from such injuries; since protection from cold can be no object in such temperate regions. The tail is of very moderate length, but extremely thick and bushy. The length is that of the jackal's tail, extending only just below the heel properly so called—the fullness considerably greater than in the jackal, but otherwise similar. In action, the tail is carried sub-horizontally; at rest, pendulously and always straight.

The head, with its integuments, is moderately elongated, broad, flat crowned, and low; the real breadth of the posterior part much increased in apparent size by the quantity and outward set of the hair on the cheeks: the face more seemingly than really sharpened—broad and short by comparison of that of the jackal—the eye, oblique and narrow, but less so decidedly than in the jackal; its pupil round: the ears, twice as large as in the jackal, broad, erect, subpointed, the posterior margin furnished at its base with the ordinary fissure: externally, covered with soft short hair,

which prevails likewise all round the edge of the cars within; rest of the internal surface, naked, but protected by long silky hair proceeding from the base and anterior margin, and extending nearly to the tips: cartilaginous part of the nose, longish, somewhat acuminate; the muzzle and nostrils, sharper and smaller than in most tame dogs—blunter and larger than in the jackal. If the face of *Búánsú* be characterised justly as elongated, with reference to all domestic dogs but greyhounds, this is to be attributed to the length of the cartilaginous—not of the bony—part of the nose.

The skull, or head *without* its integuments, is such as, with reference to the whole of its characters, and especially that most important one the ample swell of the parietes, to point out this animal's place in the Second Section of CUVIER.

It being admitted that the intelligence of dogs varies exactly as the size of the encephalon, the fact that this entirely savage race has the brain as finely developed as in the most sensible of our cultivated breeds, and much more so than in the majority of them, offers a curious subject for speculation; the more especially as, so far as I have seen and heard, the inference from the size of the cranium is justified by the sagacity of the animal. Are, then, all our pains bestowed or vainly or mischievously upon this favourite object of our care? and is nature, after all, too much for art? I confess it seems to me probable that the stern necessities of the savage life may more effectually elicit the intelligence of the Dog than all our factitious devices. Man, with his peculiar gifts of speech and reason, is the true object of education: and it is very possible that, in respect to all other animals, the “noble savage running wild in woods” has more sagacity, properly so called, than any tame individual of his species, however long and carefully nursed and trained. The nasal bones are shorter than in the spaniel—much shorter than in the jackal; and

the posterior halves of them, instead of being bent concavely as they approach a considerably elevated forehead—as is the case in all domestic dogs, are bent convexly, uniting insensibly with the arcuation of a low forehead. There is consequently very little transverse dip or depression in the fore part of the head: and indeed the entire vertical line of the skull approaches, by its pretty uniform and gentle curvature to that of the hyæna,—a form of head of which the true type is to be sought in the *felina*: Frontal bones, lower and flatter than in any domestic dog—rather higher and more arched than in the jackal, much more so than in the fox. Frontal processes or brows, small, but rather larger and fuller than in the jackal or fox. Frontal sinuses, not inconsiderable notwithstanding the lowness of the frontal bones; their want of development upwards and outwards being compensated by a larger longitudinal range than is usual with domestic dogs. The extent of *anterior* development of the frontal sinuses in the *Búansú*, and their connexion with the nasal cavities and with the brain, are, in particular, more striking than in any domestic dog's skull I have had an opportunity to examine: and perhaps in these peculiarities, taken in connexion with the superior elongation of the cartilaginous portion of the nose, we may find the true explanation of the Wild Dog's superior powers of smell, despite the inferior development upon the whole of his frontal sinuses, as compared with that of the same sinuses in the spaniel. Parietals, as largely developed as in the spaniel. There is somewhat less amplitude anteriorly, near the frontal sinuses: but it is compensated by greater enlargement posteriorly and inferiorly. Great longitudinal and transverse crista, medial. Rami of the lower jaw, very little bent; and the condyles, consequently, scarcely raised above the line of the upper cheek teeth. The upper maxillary bones less compressed, and the lower jaws more separated, and the intermaxillary bones more widened to the front than in the spaniel; greatly more so than in the jackal. By reason of these peculiarities the incisor teeth stand nearly in a line as in the *felina*, instead of being bent into a segment of a circle,

and Third Sub-divisions; and he has my full permission to place the *Búánsú* therein, provided he will pardon me for having relieved the toil of collecting and recording a multitude of facts by some little indulgence in the way of speculation upon them.

Dimensions of the animal.

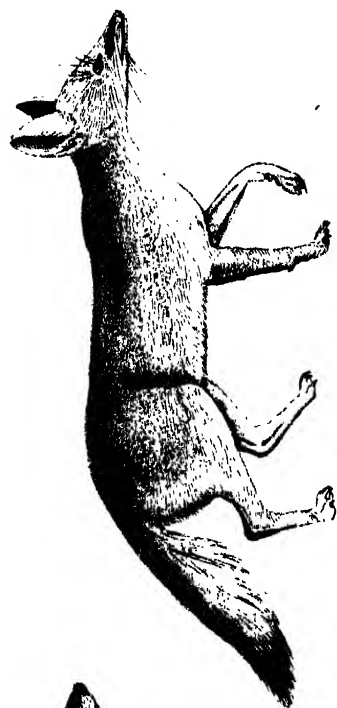
	<i>Ft.</i>	<i>In.</i>		<i>Ft.</i>	<i>In.</i>
Nape to rump,	2	5½	Length of fore-leg, to line of belly,	1	0½
Length of the head,	0	8½	Ditto of hind ditto ditto ditto, ..	1	3
Ditto of the tail (end of hair,) ..	1	4½	Length of the ears,	0	4¾
Height, at the shoulder,	1	8½	Snout to fore angle of eye,	0	3½
Ditto at the hip,	1	9¼	Thence to the occiput,	0	5
Depth of the chest,	0	8½	Weight (thin) 30 lbs.		

Dimensions of the skull.

	<i>Ft.</i>	<i>In.</i>		<i>Ft.</i>	<i>In.</i>
Extreme length,	0	7 ⁵ / ₁₆	Length of lower jaws from the condyle to the symphysis of the jaws in front,	0	5 ⁵ / ₁₆
Extreme breadth (between the zygomatic processes,)	0	4 ⁵ / ₁₆	The same from the former to the posterior edge of the last molar tooth,	0	3 ⁵ / ₁₆
Extreme height,	0	3 ⁹ / ₁₆	Length of upper jaw, from symphysis of intermaxillary bones to posterior edge of last molar tooth,	0	3 ¹⁰ / ₁₆
Greatest breadth between the temporal bones,	0	2 ¹⁰ / ₁₆	Symphysis of intermaxillaries to foremost edge of orbits, ...	0	2 ¹¹ / ₁₆
Symphysis of intermaxillary bones to posterior points of nasal ditto,	0	3 ⁶ / ₁₆	Thence to end of crista occipitalis,	0	4 ¹⁰ / ₁₆
Thence to the coronal suture,	0	2 ¹ / ₁₆			
Thence to the posterior extremity of the skull, or end of crista occipitalis,	0	2 ⁴ / ₁₆			

N. B. These latter measurements (of the skull) are rectilinear, taken with calipers—and not drawn along the curves.

NEPAL RESIDENCY, *July* 1, 1832.



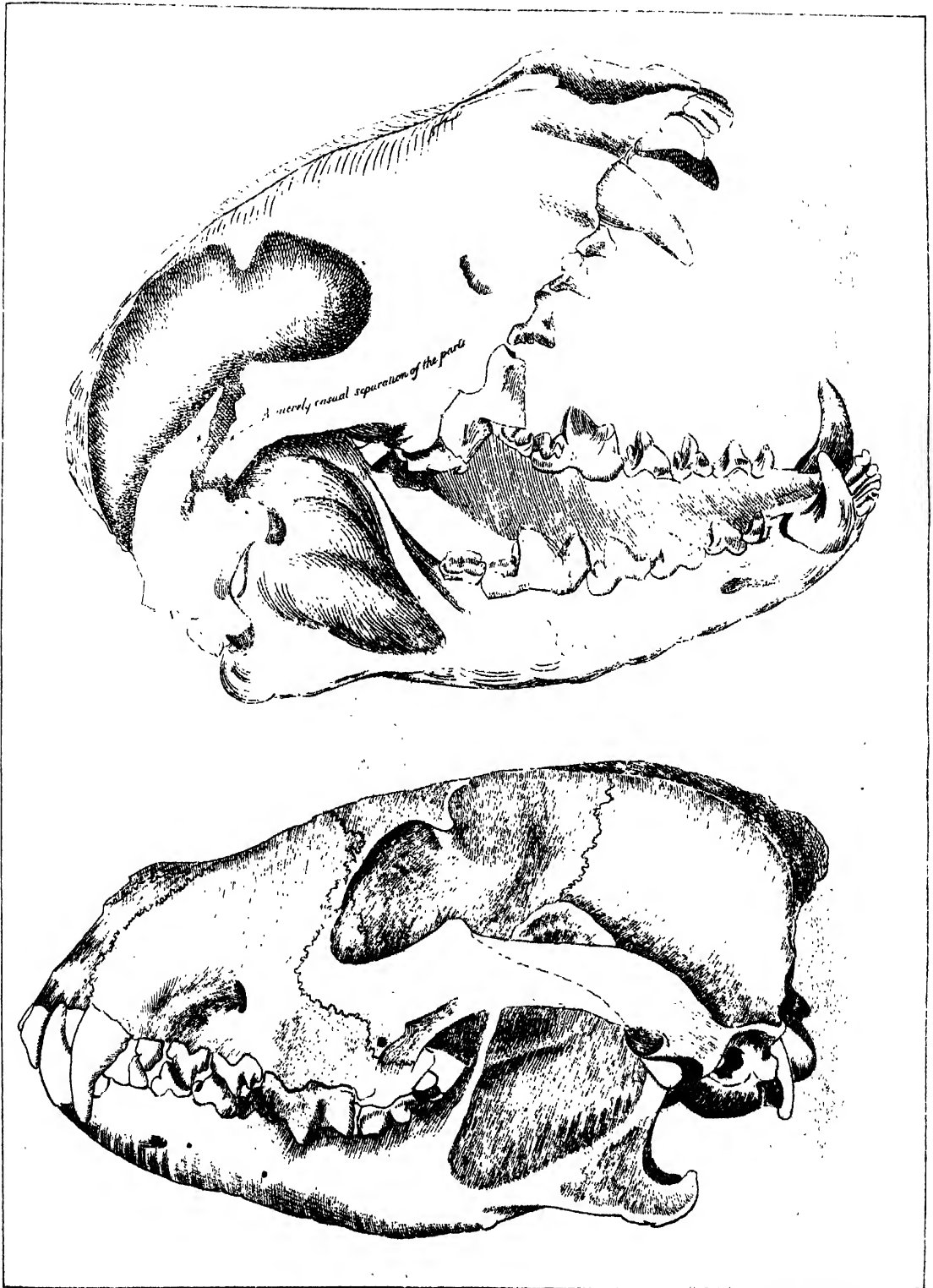
*Canis vulpus Indicus (michi) the Linnæi.
Indian Fox.*



*Canis aureus Indicus (michi) the Sygal or Shaghal
Indian Jackal*



*Canis Pratericus (michi) the Bissau of the Vepulor.
Indian Wild Dog.*



SKULL of the BU'ÁNGU

J.B. Tassin lib.

Comparative view of the skulls of the Wild Dog. Jackal & Fox of India, designed to show their general forms merely.



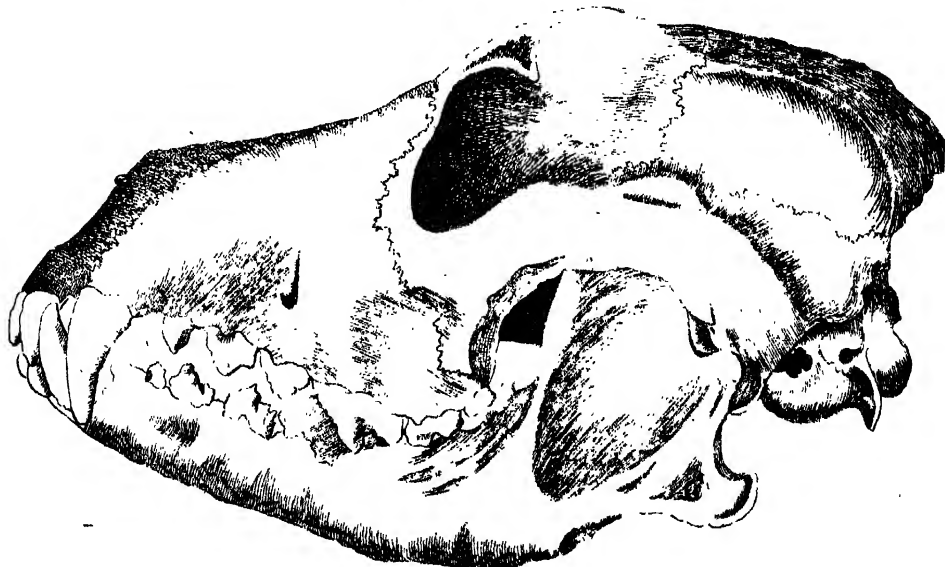
Jackal



Fox



Skull of the Páridar or Chien de Rue of India



A P P E N D I X.

CANIS AUREUS INDICUS, scarcely differs, as a variety, from the type of Pallas and Guldensadt: is two feet long and seventeen inches high: the head seven, the tail eleven and half, the ears three inches in length: Above, dark or iron gray, with a pale rusty tinge—below, whitish: tip of the tail and a patch on the chin and on either fore arm, blackish: weight twenty pounds. Feeds chiefly on carrion, preys by night, is fearless and familiar, found every where, seldom abroad by day, does not usually burrow.

CANIS VULPES INDICUS, new: has some affinity with the *Corsac*: is twenty-one inches long and twelve high: the head five, the tail twelve, and ears three and quarter inches in length: Above, pale or ashen gray, with a very pale rusty tinge—below, yellowish; a dark line from the eyes to the nostrils: Tail reaching to the sole of the foot, black-tipped. Remarkable among its congeners for the acuteness of its canine teeth and of its nails. Feeds chiefly on insects and vermes, preys by day and by night, constantly abroad by day, very familiar, resides in burrows on open dry plains, found all over India, excepting the hills. Weight seven to eight pounds.

XV.

OBSERVATIONS

ON THE

SPÍTÍ VALLEY

AND

CIRCUMJACENT COUNTRY WITHIN THE HIMÁLAYA.

BY SURGEON J. G. GERARD,

BENGAL NATIVE INFANTRY.

PART I.

It had long been supposed upon theoretical inferences and conclusions, deduced from accordant but vague information, that the chain of mountains which defines a natural boundary between *India* and *Thibet*, recognised as the *Himálaya*, had a corresponding but less rugged declivity on the north, which sinking into a table land, undulated with a downward slope and spread out into a plain, and that the whole level of the soil immediately assumed an opposite declension to that of *India* on passing that lofty crest. But on crossing various ridges at elevations between fifteen and sixteen thousand feet in altitude, by the course of rivers which had their origin on the southern slope, the snowy zone was found to be of great

breadth, and, instead of an insulated line of peaks, to present consecutive ranges, or detached clusters of summits rising in rivalry, and even transcending the hither precipitous cliffs which appear from our plains in such gigantic desolate grandeur. The passes into the interior of the country were observed to run upon a higher line of level, and the streams to ramify many days journey within the snow-girt region, as the branches of the *Ganges*, *Jamna* and *Chínáb*, or like the *Satllej*, to pursue their course through the chain, deriving supplies from its northern skirt, and the high land at the back of the peaks, or penetrating more remotely, and receiving accessions from more inward regions and higher table land, as the *Indus*. In this vast alpine tract, no line has yet been discovered that marks an opposite slope to the rivers, nor have we any grounds of inference for the probable limit of that lofty level, of which the *Ganges* and *Indus*, with the *Panjáb* streams, may be considered as defining the southern declivity, and the *Brahmapútra* and *Oxus* the eastern and western slope; but nothing is known or conjectured of a northward or north-eastern boundary, and we still remain ignorant of the extent, the altitude, and the nature of the great central platform of Asia.* Lake *Mánsarovara* may be indeed assumed as the highest point of the Indian Peninsula, forming a plane which throws off the great rivers from south-east to north-west, and the base of clusters of peaks insulated between their sources and the northern slope of the plateau, of which all our knowledge is still confined to conclusions from the upper course of the *Satllej* and *Indus*, where the basins of those rivers, and consequently the lowest depression of the soil, have been ascertained to rest upon the zone of fifteen thousand feet, and the table land, through which they roll, to rise beyond seventeen thousand. These are but approximations to the altitude of the broken plains of *Tartary*, which only serve to prolong conjecture as to the extreme verge of the highest lines of level. All the waters from the northward deflexure of

* Baron HUMBOLDT's Researches were not known to the author, when this was written.

this mass of mountains, from the great *Kylás* chain and table land on both sides of it, running into the grand rivers, which form the Peninsula of *India*, or intersect the Gangetic plain, or tending towards an aspect comprehended between the debouchures of the *Brahmaputra* and *Oxus*. In crossing the remotest accessible points of the snowy barrier, or winding round the bases of its detached peaks, we find the declension of the soil every where, towards the hollows which drain off the southern waters, marked by innumerable rapid torrents throughout a reticulation of levels, which opening into a common trunk or lateral valley, pour their tribute into the great rivers.

On the north-western frontier of *British India*, the *Satlaj* is the centre of this system of rivers, collecting in its downward course from *Mansarovara*, streams from the northern skirt of the *Himálaya* on one side, and the high table land on the other, which, rising in bluff undulations, terminates in a rival crest (*Kylás*) which sends its waters to the *Indus*. At the deflexion of the *Satlaj* at *Shipke*, (Chinese Government), it receives similar feeders from the high ridge of *Paralássa* on the north-west, and others from the north, to the limit which turns the declivity of the soil towards *Ladák* and the *Indus*, and on the south the liquified snow of lofty mountains which have their corresponding base washed by the streams of the *Ganges*. In this area of intersections, the river *Spítí* is the great trunk descending from clusters of peaks at the heads of the *Chandrbága* or *Chínáb*. It meanders through an inhabited valley, and debouches into the *Satlaj*, at the village of *Namgea*, in *Kunáwer*, where the stream is elevated eight thousand six hundred feet. Like the other *Intra Himalayan* rivers, its slope decreases with the rise of its course, opening out from a narrow rock-girt channel to an expanded bed of sand and alluvial sediment, and towards its source creeping sluggishly round the roots of the cliffs. At its conflux with the *Satlaj*, it emerges from a gorge, or mere fissure, between perpendicular walls of granite rock.

At the villages of *Chango* and *Shídlkar*, twenty miles up the stream the banks exhibit horizontal strata of water-worn pebbles, loam, marl, and finely attrited sand, with occasional imperfect traces of fossil exuviae at heights from one to two thousand feet above the river's bed, or eleven to twelve thousand above the sea. The channel continues sharp, but is here little hampered by rocks. The mountains of a gravelly structure, rising out of the dell on each side to the verge of twenty-two thousand feet, are almost bare in summer, the marginal snow resting close to their tops in a narrow but well defined belt. At the fortified rock of *Dánkar*, the bottom of the valley attains its maximum expanse, which is here flat, sandy, and intersected by the stream: the mountains, forming a steep rugged boundary on each side, are indented by water courses, which, descending abruptly from the snow, swell the river to nearly the size of the *Satléj*. Villages and cultivation are thinly sprinkled along the banks. In summer, the climate is mild and even sultry, notwithstanding the great elevation of the soil, and dense crops of wheat, barley and pease ripen in August and September. The winters are proportionally rigorous, but the sun's rays are always extremely ardent, and when the ground is sheeted in snow the reflected glare is intolerable to the eyes.

The forks of the river are near the village of *Lossur*, the last inhabited spot in the dell where the stream has an actual elevation approaching to thirteen thousand four hundred feet, winding with a slow declivity in a broad pebbly bed round the feet of the mountains, here presenting an almost mural scarp to their near summits, which are flat or slightly inclined, but the ravine continues beyond *Lossur*, and receives the remotest feeders from the recesses of the *Paralássa*, which is here the limit of the plane, and gives a northward slope to the waters in the origin of the *Chínáb*. The valley of *Spítí* is thus comprehended between the heads of that river in latitude about 33° , and the *Satléj* in $31^{\circ} 15'$. The course is south east, flanked by snowy mountains on one side and the

declivity of a loftier chain sloping to the table land of *Rúpshú* on the other; the more precise boundaries of the district being, the hill-rajship of *Kúllú* and the *Himálaya* south-west, the *Satlej* and the British Territory of *Basáhir* (*Kunáwer*) south-east. Snowy ridges and high tabular land to the *Indus* north and north-east, and the *Paralássa* mountains with the branches of the *Chandra Bága* north-west, including an area of about ten thousand square miles drained by the *Spítí*. From the southern base of the snowy zone to the valley of the river is a geographical distance of fifty miles, and an equal space in the same line of direction (north-east) falls over snowy mountains, belts of table land and ridges, which, though only capped with snow, do not yield in elevation. The great lines of level continue rising to the *Indus*, and the land, sloping up to the north by successive ranges, at last opens into a continuous plain inhabited by Nomade races, who live in black tents, and migrate with their flocks in search of pasturage. These are the *Huns* and *Mongols*, whose figures are described as very hideous. All hither to that limit, including the upper portion of the *Satlej* and its ramifications and even the valley of the *Indus*, considered by European geographers as table land, is but the rugged skirt of this great plateau; a tract of country unseen by the eye of civilized man, and almost inaccessible to the natives of any other region. The skies are here so arid that little snow falls even in winter and is only perennial in the loftiest spots. The section of country made by the *Spítí* and its tributaries, though cutting the northern base of the *Himálaya*, presents a singular contrast to its opposite or plainward aspect, not only in climate and vegetation, but in the condition and character of its inhabitants, and in geological structure, the rocks themselves appearing new and all the productions of nature different.

A traveller entering the valley by the sources of the *Chúnáb* and *Paralássa* chain on the north-west, and tracing down the river, particularly remarks the steep and insular form of the cliffs on each side. Where

the hollows of streams take their course, they appear like lofty islands with their erect bases, planted in the sand, and their almost mural sides ending in a flat top on a plane sloping outwards. Near the head of the valley these tabular masses are sheeted in snow. In the descent of the river the marginal rocks terminate in a sharper crest, and sink with the level, but the snowy zone upon the north, though more remote, preserves a very lofty line, displaying erect peaks with slanting summits, like the crest of a wave that has gone by. The structure of the rocks is generally a packed or scabrous limestone, the stratification of which is arrayed in nearly horizontal belts, super-imposed upon each other in layers like benches, having their vertical faces to the river, and their dip inclined outwards at a very small angle with the horizon, which gives their declivity a very regular slope, that sometimes breaks off abruptly, but commonly softens into heaps of soil, like the undulations of the sea, producing furze pasturage for cattle: but the faces towards the river are too steep and rugged for any species of vegetable covering. The entire features of the country are extremely arid, with no natural verdure or cultivation, except through the medium of irrigation. The valley is but thinly inhabited, owing to the absence of streams for agriculture; the villages are consequently far detached along the step of the river, at a varying level between eleven and fourteen thousand feet; yet cultivation which, upon the Indian exposure of the mountains, shrinks and ceases beyond nine thousand five hundred feet, here maintains its ground and assumes even a denser character at belts of elevation, which often correspond to the marginal limit of the snow upon the southern aspect of the mountains, or the line of fifteen thousand feet. These cultivable spots occur along the course of adjunct feeders of the *Spítí*, or in open hollows facing to the sun between the marginal rocks of the dell and the parent ridge which defines the levels on either side. These villages, though subjected to night frosts during more than three parts of the year, and the keen rigors of a protracted winter,

are more densely tenanted than those in the trunk of the river, where the patches of soil for cultivation are dry, rocky and baked; and the fields, eaten away by the stream on one side, and hampered by the attrited splinters of the cliffs, (which are constantly accumulating,) must in time become extinct. This desolating influence, though slow, is irresistible, and all the villages will eventually disappear under it, and the whole shelf of the river be turned into a desert: the very cause which has opened the country to the abode of mankind, will overwhelm it, and when the mountains, from gradual abrasion, no longer bear any snow, the river itself will be dried up.

The tributary villages, or those not actually in the dell, are planted high above and behind the terminal rocks upon a waving slope in the midst of a black argillaceous soil, which from its open situation, is permanent. The loftiest tenanted spots that have been barometrically determined, rest at fourteen thousand seven hundred feet, and crops of beardless barley extend to the verge of fifteen thousand. Men, animals, and vegetable productions succeed better here than in the valley below, all thriving profusely in a zone that contracts and terminates every trace of plants in the Andes under the Equator; nor is it at all improbable that the interior and flatter continuity of the country may nourish a cultivable soil in a much loftier region, where increasing aridity and solar reverberation tend to a higher limit of the Isothermal lines. At the extreme altitudes where grain ripens in *Spítí*, the summer temperature, though considerable, is of very short duration in an atmosphere where the heat dissipates so rapidly that the nights are keen even in July; hoar frost sometimes appearing near the fields upon the highland and vallies of *Rápshú*, where the want of water for irrigation baffles all attempts at agriculture. It freezes throughout the whole year, and so early as the middle of September, the morning temperature was found between 13° and 17° , while in the day time it reached to 58° . Upon the declivity of the *Spítí* valley, in the

early part of October, at permanently inhabited spots, the thermometer usually pointed between 14° and 16°, once 12°, in a hollow surrounded by dead sand hills, and five thousand feet below the level of the eternal snow; thus giving a frightful presage of their winter, against which the people are, however, well provided through the Sun's unintercepted rays and their comfortable houses, their clothing, and even their food; but fuel is so sparingly procured, that during the day a fire is rarely to be seen, though always at command amongst people who, enslaved to tobacco-smoking, are individually accoutred with flint and steel, and the furse so dry and brittle as to ignite even when growing.

Animals of every description derive a woolly covering from the effects of their arid climate. The *yák*, the dog, and even the horse, all partake of this provision of nature, but the human race in this respect is more defenceless than in other Asiatic countries, being denied all beard, while their black bushy heads seem to be insensible to the *Thermal* changes. The *Lámás* or Priesthood are, by their creed, always uncovered, and their black hair being thick set and closely cropped, give them a frightful appearance, like Banditti. There is a characteristic aspect here in every thing, which betrays a foreign influence. From the soil to the skies the whole is new to the eye and strange to the feelings. In animal life, this is peculiarly displayed in the shawl goat, the *yák*, and a species of sheep; and to the dryness of the climate more than to its rigors is owing the singular physiognomy of the landscape. The silky softness of the goat's fleece, and even its existence, depends upon the arid air and vegetation; all attempts to naturalize it even in adjacent tracts, however cold, have failed, and must continue to fail even upon a more precise principle than that which regulates the migration of plants, for it is not heat but moisture that is here inimical, and both are combined immediately on passing the snowy crest towards India. In their own country, their only pasturage is tufts of spiked gramina, so brown as to

be scarce distinguishable from the surface of the excoriated rocks—for when removed from under their native skies to however elevated a region, they cease to live. Solitary individuals out of large flocks have, indeed, by great care survived a certain period upon the hither side of the *Himálaya*, and have even reached the plains of India;—but in no country apart from their own bleak elevated pastures, can the species be preserved. It is the same with the *yáks* and the sheep which have black heads and feet : they may be acclimated upon the very border of their native soil, as in *Spítí* or *Kunáwer*, but the wool degenerates, and the animals themselves out-grow their status and proportions. On transplanting them to the southern hills where vegetation is rank and verdant, they find no nourishment, droop and die; those which survive exchanging their soft fur for one of coarse hair. Even in neighbouring districts, beyond the influence of the periodical rains, and in a very cold climate, though the animals seem to thrive, the fleece of the goat deteriorates, and upon the hither side of the *Himálaya* becomes extinct. The deserts of *Thibet* are their natural soil, where they feed upon a prickly stubble or heathy like grass, scarce visible to the eye, yet myriads of these beautiful animals checquer the almost barren slopes of the mountains to which they seem destined, and it is futile to pursue the experiment of acclimating them to European countries, which will be found a mere illusory advantage, for even if they survive, it is certain that the third or fourth generation will lose their identity, and the fine wool entirely disappear.* The sheep of the table land have an equal peculiarity of habit, and are even more difficult to naturalize.

* Captain TURNER, who visited *Thibet* in WARREN HASTINGS' Government, brought down several Yáks and Shawl Goats, which were transported to Europe in safety, and a Yák actually lived in Mr. HASTINGS' park for several years. Mr. MOORCROFT was equally fortunate in the Goats he carried away from the Table land near *Mánsarovara*, which also reached England. Those subsequently imported into France have indeed survived under the advantages of a route by the Caspian sea, through an arid country, and the care of a Physician who expressly attended them, but though the animals are considered to be thriving, it remains to be seen whether the fleece will preserve its natural softness.

They are remarkable for size, and the quality of their wool and flesh, and a long and very small black head, with legs and feet of the same colour. These immense animals are used for the transport of grain, salt, tincal, &c. &c. They pasture upon the leafless plains of *Chúmurtí*, and the high table land, all along the forks of the *Indus*, being indigenous to the whole of *Thibet* from the limit of *Yarkand* to the east of *Lhassa*. They come down in vast flocks to *Spítí* in the autumn for grain, but though here in a tract of country arid and desolate to the last degree, they cannot be reared with any advantage. In the deserts occupied by the Nomade tribes, both the animal and its fleece reach a finer standard, and there the climate is drier, and vegetable productions more scanty. Horses alone undergo the transition from their elevated pastures, but they lose the woolly covering that invests the roots of their long hair: the wild animal has never been domesticated in any situation. Both would appear a priori to have a common origin, yet the circumstance of their eluding every attempt to tame them when caught, and their uniform speckled colour of fawn and white, and their wild agility, demonstrate them to be distinct species.

The inhabitants of *Spítí* afford even ampler traits of distinction than the animals; a community of condition arising from individual penury has generated reciprocal ties of social attachment. Though poor in those resources which denote easy existence, there is nevertheless a degree of comfort in the necessities of life amongst the lowest classes unknown to the natives of the southward hills, where indolence and insulated habits have alienated those feelings of concord which make even poverty agreeable.

The common repast of the *Thibetans* consists of a greasy soup, called *Lappi*, and buttered tea: animal food is also naturally abundant in a region where pasturing flocks are almost in a state of nature, and in every house may be seen the dried carcasses of sheep and yáks, and skins

of fat and butter. They are much addicted to tobacco and fermented liquor, and upon the whole the comforts of life are in their kind neither sparing nor unsubstantial. Their manners partake of the grossness of their food ; no feeling of female delicacy prevails here, and a promiscuous familiarity and coarseness in all the habits and decorum of life reign everywhere. Their wearing apparel accords with the exigencies of the climate and the suddenness of the thermal changes. From the sheep-skin tunic to the chintzes and fine silks of *Lhassa*, which last are the insignia of the higher classes, or from the *Vazír* of the State to the Nomade of the desert, there is little in education or manners to denote distinction. Authority here, as elsewhere, claims a certain respect ; but the only courtly deference I observed in my interview with the *Khárpán* of *Ladák* (and this seemed to be due to me rather than from me) was during dinner, which we eat together in the midst of his greasy attendants, who devoured the fragments with voracious appetite, licking their fingers and then their plates, which were afterwards lodged within the folds of their woollen garments, or between them and the skin.

Strangers, especially Europeans, arriving amongst them and passing rapidly on their way, see nothing in the country or inhabitants to raise a favorable impression in their mind. They observe them in black bare-headed groupes, timid, squalid, and in rags, and every third person a priest ; but, however unintelligible their conduct when debating in an unknown dialect about supplies, or the propriety of our progress, (both of which are doubtful in such a territory,) in their houses we were treated with friendship and hospitality, unaccompanied by that savage feeling which protects a traveller as a guest, and betrays him beyond the threshold of his sanctuary.

The complexion of the people is darker than might be assumed from the influence of so cold a climate, but the solar beams are equally or more

ardent in an atmosphere, which, by its want of humidity, excoriates to brittleness every trace of vegetation, and parches to a ruddy and scabrous coarseness the skin of the face, especially in the females. The people of both sexes are naturally indifferent to shame, and alienation of chastity in the females is here a mercenary interest purchaseable upon the lowest terms. In figure they are stout, waddling and dumpy; in address, presuming and indecorous, but much of their open familiarity is the offspring of immoderate curiosity. In face they are not beautiful, even when young; when past their climacteric, very unseemly; and when old, a picture of horrid ugliness; not regardless of the aid of artificial charms, their hair glistening with rancid oil hangs loosely round their sun-burnt necks: sometimes it is woven into tresses which braid the contour of the face, but is commonly unregarded and blows out in the wind, giving them a shaggy appearance like wild beasts: their black greasy heads are embellished with *lapis lazuli*; their sun-burnt necks with amber and coral, their wrists and ancles with snow white shells, and a girdle of beads and other trinkets, all shining in the sun's rays. The men, without any superior pretensions, have their peculiarities less out of place, but they are black, greasy and imbecile, without any noble qualities whatever. Poverty and their insulated situation have denied them all pride of distinction, and subdued their feelings to one uniform level. Such is their general character, and it will apply to the whole nation of *Thibetan Tartars*. The absence of female chastity is a singular commentary to their honest and pacific conduct and the other social qualities of their natural society.

The country is every where broken into steep arid peaks, uniform sterility covering alike the mountains and the vallies. There are none of those fine contrasts of scenery which we behold in the southward regions of the *Himalaya*, where all the beauties and all the horrors of Nature are

united together in a single precipice. Cultivation is here solely indebted for its existence to irrigation, and this nutritious impulse in so dry a climate is far more powerful than the spontaneous efforts of the soil, in quarters where the effect of atmospheric heat and humidity is combined. To the climate, vegetation (such as it is) owes nothing, but rather succeeds in spite of it. The few traces which are sprinkled over the dead sides of the cliffs shoot out of the rock as if impelled by their own vitality, but in the loftier zones, where the soil is better and the solar warmth mitigated, there occur upon the slope of the strata extensive tracts of a thick set prickly bush, which in appearance resembles the surface of a Highland heath.

The villages in the valley itself are planted upon an alluvial slip on each side of the river at long distances, and are indicated in summer by their verdant environs, and in winter by their black appearance in the waste of surrounding snow. The crops of this region are dense, but have little variety. The staple grain is *Ooa Jáo*, or beardless barley, peas, turnips, and in a few spots *Phapra* and mustard, the seed of which last is expressed for oil. The fields are sown in April and May, the seasons varying with the level, and in the elevated belts by the hollows of tributary streams; where the winter is protracted, the soil is cleared of snow by sprinkling black earth over it.

Notwithstanding the almost perennial night frosts at those extreme limits, and the severity of the climate during the sun's southern declination, the crops are even denser here than in the dell below.

As the cultivation of farinaceous grains chiefly depends upon a certain degree and duration of heat (which, in these regions, is found quite sufficient in July and August, without relation to the rigors of the previ-

ous or subsequent months), it was an oversight which this physical fact led to in the inference that the *Ooa Jáa*, or Tartaric barley, might be acclimatèd to the mountains of Northern Europe. The excessive cold that reigns at the highest cultivable levels of the *Intra Himalayan* regions during the greater part of the year, in no way cramps the progress of vegetation, since this is effected by the necessary quantity of heat during the appropriate season, and which, though perhaps never so considerable as in Southern Europe is more constant: and the solar rays of this parallel of latitude, in so thin and transparent an atmosphere, are infinitely more powerful; to such an extent, that the difference between their direct ardor and the shade is often more than one hundred degrees, and the contiguous slopes of the same ridge, within the space of a few hundred yards, present torrents of liquid snow and streams of unthawed ice.* These facts, and their effects upon the constitution of men, animals, and vegetation, are not properly understood in Europe, or if known, are explained upon theoretical assumptions which have no grounds of existence in nature.

The feebleness of the sun's rays in any part of Europe must render the mountain acclivities, of even moderate elevations, inimical to the success of the Tartaric grains, though the degree of cold there never approximates to that which reigns in the high zones of *Spítí*. Of this we have analogies

* It will scarcely be credited that in the beginning of September, upon the Northern slope of the *Paralássa*, at an elevation of fifteen thousand five hundred feet, a thermometer resting upon the rocks marked 158°, while the temperature of the air was 55°;—again in the middle of October when the Sun's Southern declination is already great, at the Chinese village of *Langtcha*, elevated more than fourteen thousand five hundred feet, the sun's rays absorbed by the sand had a temperature of 130°, while the air was 46°. In the end of the same month, in a valley flanked by lofty rocks, but at an elevation of twelve thousand feet, a thermometer stood in my pocket at 105°. Wherever we go we find the sun's rays oppressive, and much of our surprise at the high zones of inhabitants, and cultivation, ceases when we become acquainted with these circumstances.

on the Southern or Indian slope of the *Himālaya*, where, in a distance of only a few miles, and frequently within a few hours' journey on the corresponding aspects of the same ridge, we find cultivation checked, and altogether extinct on the verge of ten thousand feet, owing to the insufficiency of the summer heat at this limit, notwithstanding that the winter season here, in respect to mere cold, is far less severe, and the mean value of the climate much superior to that of the *Intra Himālayan* regions where grain is exuberantly cultivated. The climate of *Spítí*, notwithstanding the great elevation of the soil, unites the extremes of sultry heat and excessive cold; while the sun's rays are always intolerable, and in winter, strike with an ardor proportionate to the keen rigidity of the ambient air. At this period, when the country is sheeted with snow, exposure scorches the face and inflames the eyes even to the loss of sight, the glittering expanse is here made more brilliant by the reflection of skies of the deepest azure, even as black as ebony. On the first day of November, after a fall of snow, and in a temperature of 25°, I was fatigued by the sun's rays striking through a thick coat, and while feet and legs were undergoing a constant transition of thawing and freezing, to me at least the solar heat felt the most distressing, till the road deflecting round a bluff angle on the margin of the river brought us into the shade, where a bitter cold struck us to the bones, congealing the moisture of respiration, and the clothes on our backs and our legs, which in the ford of a torrent, came out at each step stiff with ice. From this time the mercury daily pointed near the zero of the scale, once two degrees below it, and probably did not rise, and must have fallen many degrees in the subsequent four months. What the cold arrives at, when the sun reaches his southernmost declination, is a conjecture that may be safely hazarded at—20° or—25° for the inhabited spots in the valley, and at the villages on either side of the limit of nearly fifteen thousand feet, it can be little above the freezing point of mercury.

The winters are followed by a degree of warmth equal to the summers of the south of England, and a far more powerful sun, but with a more variable diurnal temperature. Upon the elevated table land of *Rúpshú*, or at the tenanted environs of *Spítí*, whatever be the degree of midday heat, it flies off so rapidly in the thin air, when the sun ceases to shine, that the nights of those regions offer an extreme contrast in their chilliness, the range of temperature in the twenty-four hours often exceeding 40° . In insulated elevations this would not amount to 15° . Towards the end of August, the climate of the middle regions of *Spítí* had a day temperature of 83° ; and clouds of dust wheeling along the river bed, and sometimes a weak and transitory peal of thunder gave the scene a more tropical complexion than would readily be conceived possible at an elevation between twelve and thirteen thousand feet above the sea, and in a parallel of $32\frac{1}{2}^{\circ}$ of latitude. At *Dankar*, which verges upon this last level, my small tent was but a feeble screen against the solar rays, the thermometer on the table rising to 110° ; but in so rarified and elastic a medium this accumulation of heat is very fluctuating, for, when it rains, the air at midsummer is chilled down to a degree very uncomfortable to the feelings, and the cliffs in the immediate vicinage of the villages are often sprinkled with fresh snow. In the vallies of *Rúpshú*, at a mean elevation of sixteen thousand feet, where the maximum temperature may be estimated at 75° , it snows occasionally in July, and freezes always at night*; yet such and even loftier situations

* MOORCROFT, in traversing this tract at midsummer, encountered a fall of snow, which however vanished during the sun's course. M. CSOMA DE KÖRÖS, the Hungarian traveller, had a more frightful picture of the rigor of the climate in an adjacent tract *Zanskar*, where, on the day of the summer solstice, the ground was sheeted with a fresh fall of snow, and in the beginning of September the same scene was renewed while the crops were still uncut. MOORCROFT when encamped on the shore of Lake Mansarovara, had his tents covered several inches deep with snow on the 10th of August, with frosty nights in July, when approaching the forks of the *Indus*:—facts of themselves (in so low a parallel of latitude,) demonstrating vast height, and in connexion with analogous observations upon the Isothermal lines in *Rúpshú* (if we had not Barometrical levels of the *Satlej* at *Shipké* and *Behlar*, and Captain WEBB's depression of the river from *Niti* pass) affording presumptive inferences for placing that lake upon the very verge of seventeen thousand feet.

are the pasturing regions of innumerable flocks, where it is difficult for the eye to detect any nutritious vestige.* The marginal limit of the snow, which upon the sides of *Chimborazo* occurs at fifteen thousand seven hundred feet, is scarcely permanent in *Thibet* at nineteen thousand, and upon the southward aspect has no well defined boundary at twenty-one thousand feet. From an altitude approaching to that line, and which was bare of snow, I was in view of a distant chain, the detached peaks of which appeared under an elevation of some minutes; yet a few traces of snow, like ribbands, only remained on the last day of August. My own position was here at the edge of the snow, from which to the bed of the *Spítí*, at a perpendicular depth of ten thousand feet, was a continuous bare slope. The opposite (northern) declivity was indeed sheeted in snow to the bottom of a deep dell, and all beyond me was uniformly white.† If the objects

* A late traveller, M. TEMPLAND, has discovered in the Peruvian Andes similar scenes to those in *Thibet*, the level of towns and cultivation having there an altitude of between twelve and fourteen thousand feet, and the highest inhabited villages and fields rising to nearly sixteen thousand. The crest of the mountains is proportionally elevated, two peaks having been determined at twenty-four thousand and twenty-five thousand five hundred feet respectively: the *Himálaya* are still superior in actual height, and greatly surpass the Andes in the medium of a large tract of lofty level, and the interior regions, which already begin to present a more gigantic display, are wholly unexplored.

† This spot is upon the northern verge of *Kunáwer*, conterminous with the Chinese frontier, and immediately above the Hamlet of *Changrezing*. The extreme ascent was effected upon the 31st of August, the preceding night having been passed at an elevation of eighteen thousand feet: even here we found ourselves so much exhausted by the rarefaction of the air that every movement was an exertion. Though the wind had a temperature of 42°, the sun's rays were so harassing as to force us to screen our faces, and for my own part literally to envelope myself in a blanket.—Somnolency, languor and sickness affected us so much that we lay all day in hollows amongst the rocks, without thinking of our situation or the chilliness of night. We slept in the open air under a calm resplendent sky and a temperature of 19°, that of the ground we lay upon being 14°, yet we did not suffer great inconvenience except when the puffs of cold wind crept in upon us, and congealed the moisture of respiration. The ascent from this spot (short as it was) occupied us upwards of three hours, and latterly our progress was beset by debility and such a sense of suffocation from the partial inflation of the lungs as almost overpowered our utmost efforts to move. I do not think we could have ascended much higher at that time, had it been practicable. At 1 p. m., the Barometer stood at 14,220 inches in a temperature of 30°, which computed from cotemporary observations at Calcutta, indicates an altitude exceeding twenty thousand and four hundred feet, a result which may be depended upon as being

I beheld from this lofty station were fifty miles distant (and the eye traversed a large tract of intervening country,) the difference between the apparent and true level would of itself amount to fifteen hundred feet,

farther verified by the observation of several contiguous peaks, whose height had been fixed trigonometrically from various lofty positions by my brother, Captain ALEXANDER GERARD. One point, in particular, which flanks a pass communicating between *Kunáwer* and *Spítí*, and elevated twenty thousand and five hundred feet, had the smallest appreciable depression, and the convexity of the level at the distance of my station, absorbed the trifling excess of height in the peak. On my north was a detached group of white tops concluded, from the angles they subtended, to be twenty-four thousand feet above the sea; the marginal snow occupying a very narrow belt, but the surface unbroken by a single dark peak. Beyond them appeared the chain of bare peaks in a very sharp outline. I took the angles of various points. Some were upon the plane of my own level, but generally all were a few minutes higher, and as the view was intercepted by an adjoining ridge, I could not ascertain the limits of their height or extent. Their sides were very precipitous, and from their reddish and often pale appearance, I concluded their structure to be gravelly or of sandstone, of which their configuration gave every sign. Their steep and conical crests seemed to have assumed that form by the wearing away of the surface: some were entirely naked, and where the snow rested, it was in patches or stripes in the course of hollows. The ground at their base was very rugged, and had an apparent elevation of eighteen thousand feet, the rock displayed itself below like granite, overtopped by the red formation; whatever it was, I am the more inclined to this belief from the occurrence of vast blocks of granite in a gorge which crossed my ascent, having been disclosed by torrents from the snow; while, at my nearest appulse to the summit, the rock was not connected, and seemed to run into a secondary series. The extreme tops at an estimated altitude of between fifteen hundred and two thousand feet higher were perfectly white, and had a bluff contour as if derived from the elements of their structure. The highest point of the bare ridge appeared at the verge of interception by the slope of an adjacent mass of mountain which was cut off from my position by a deep dell, but I have no doubt that loftier objects were to be seen, those in view being sufficiently indicated to authorize the inference,* and being accessible points as far as physical obstacles are concerned, they hold out to adventure a prospect full of interest with relation to the structure of such elevated masses, and the observation of the unknown regions beyond them which have not even a mark in our maps. The sun's rays were very distressing here, but they seemed to be showered down with triple ardor upon the chain of conical peaks till they glowed in the effect of their desolation like a towering outline of volcanoes, to which impression their form and aspect bestowed an image of reality. Some very distant snowy peaks glittered in the horizon towards *Rípshú*, but the great chain which lay to my north in passing over that tract was not visible, and as it runs behind the bare ridge and is sheeted with eternal snow, its summits must be vastly elevated. Part of the same chain was, however, descried from *Parkeul*, rising out of the table land in a line of whiteness, my own level being here nineteen thousand and five hundred feet, and the intervening country between me and the objects a little under it all black:—a still more eastern portion seen from near *Behlar*, had an appreciable angle of altitude from a base of eighteen thousand two hundred feet, and at a vast distance.

but some of the points subtended an angle approaching to half a degree, thus arguing an absolute height exceeding twenty-two thousand feet free of snow. The outline was very steep and sharp, and the peaks of a reddish colour, from a gravelly or sandstone structure, had a most desolate appearance. The contiguous level, though very lofty, was still rugged, and where the surface of the country is more even, we may conclude a greater altitude for the seat of perennial snow; and it would seem from the oral accounts of the *Lámás*, that the inward and still distant ranges confining upon the Tartaric plateaux, exhibit no snow that rests throughout the year, not owing to any depression of the soil, but to the constant shining out of the sun; and it is no vague conjecture to entertain that tracts of land will one day be discovered, where the abodes of mankind and cultivation surpass in height the summits of the Andes, having the winters of the Polar regions, without their snow, succeeded by the summers of England.

The peculiar aridity of the *Intra Himálayan* regions is a subject connected with so many meteorological phenomena, and with so much of the conveniences of life, that it seems to open a new field to the philosopher. Things do not rot in *Thibet*, but crumble in long ages. There are neither moisture nor insects to produce decomposition. Every thing desiccates, and, as it were, stands fixed: the process of decay is slow, and superficial things gradually disappear in dust. Where there are no forest trees, timber is of great value, but here it lasts for centuries, and the roofs of the houses constructed of an argillaceous earth are actually baked by the sun's rays, till they harden like the *kankar* of the plains. Where little rain or snow falls, there are few natural agents of destruction, and we see neglected Monasteries yielding slowly to time, each winter eating away portions of the walls, while the timbers remain unchanged. Ruins in *Thibet* are the records of far antiquity; books are imperishable, for no insects attack them, and there is every probability

that literary memorials of the earliest periods may be extant in a climate and position alike favorable to their preservation. If any Antediluvian relics of the human skeleton are to be found at all, they are likely to be discovered in some part of this elevated platform.

The hygrometrical state of the air produces more important physical effects than either heat or cold, for it gives a new aspect to a country; and, in this respect, *Spítí* may be taken as an index of the physical constitution of the vast regions lying beyond the *Himáluya*, and its consideration will assist to explain some of those anomalies which have opened upon us in that hitherto unexplored quarter.

The traveller in *Thibet* is struck with the difference in the aspect of opposite sides of a ridge having in many places not more than twenty miles in breadth. The masses of ice resting in hollows of the bare rock near which no snow is visible, where the sun's rays are scorching, and the temperature of the air is very mild, for though elsewhere it would thaw in a temperature above 32° it remains permanent here at nearly 50° . I have seen torrents frozen solid in the beginning of September, where the ambient air of the spot kept the thermometer at 57° , and the ice did not appear to drop. In the southern hills, in the dry and clear months of November and December, it is usual to see water freezing in a temperature of 46° , at an elevation of four or five thousand feet above the sea, or under a barometric pressure of twenty-five to twenty-six inches, --but by increasing the density of the air by descending to a lower level it requires a much greater degree of cold to produce the same effect, and under circumstances of excessive moisture, a thermometer will fall below the freezing point and no frost take place. Contemporaneous observations made between various parts of the hills and stations on the neighbouring plain in the latitude of 31° , have verified a fact which theory has scarcely indicated, and scientific inductions (as far as I am acquainted,) are almost silent upon.

The different effects produced by various degrees of rarefaction of the atmosphere and its relations to moisture are such as make the thermometer cease to be a correct measure of temperature, for it is not the actual, but the sensible quality of it that is so important to philosophical studies. The superincumbent atmosphere upon the surface of the *Gangetic* plains in the months of November and February, when the thermometer frequently falls below the freezing point without ice being formed, is an instance of cold without its due effects, while in the mountains at a height of seven thousand feet, as at *Simla*, a much higher temperature will freeze the soil a foot deep. The sensibility of our feelings to those atmospheric influences is but too delicate. Let one contrast the damp morning chill of the plains with the frigid elasticity, and even stimulating effect of the mountain air which, perhaps ten degrees higher, gives the aspect of an European winter. In one case the air being loaded with moisture, and absorption farther checked by its density, a film of ice is only produced by a temperature of 28° or 30° . In the other, the air is so dry and subtle that it freezes by the effect of evaporation more than by mere cold. In the *Intra Himalayan* regions this power is so much augmented by aridity that ice often disappears unthawed while snow has been seen to fall when the temperature pointed to 47° . In the southward hills the air must be cooled down to 37° before this takes place.

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Every person in *India* is familiar with the peculiarly mouldering nature of the rainy season, though the heat is perhaps tempered fifteen or twenty degrees. It is the moisture which is here the element of structural decay and of oppression to our feelings. In *Spítí*, yaks are killed in the end of September, and hung up to dry when the mid-day air is at 66° or 68° . It is the absence of moisture here, that produces the opposite state, which is so sharply defined, that all the productions of nature, both animal and vegetable, would appear to be an effect of it rather than to owe their peculiar form to distant species. To this accelerated vaporization

is owing the fluctuation in level of the lakes in *Tartary*, in defiance of increasing cold. The lake of *Mánsarovara* celebrated in *Hindu* mythology for giving efflux to several rivers in opposite directions, (a metaphorical figure to indicate the point of their divergence) was not admitted, upon MOORCROFT'S assertion, to be land-locked, from ideas of the feebleness of evaporation at that great height then unknown and unsuspected ;* and though the lake does appear to have an outlet in the *Satléj*, this does not alter the question in regard to basins (inferior it is true to *Mánsarovara*, but under similar circumstances) having been found wholly inclosed ; and MOORCROFT was right as to the fact, though his reviewers could not reconcile it with their preconceived opinions. *Chumoreríl* (which is probably fifty miles in circuit) has no passage outward, though it is fed by streams which have a broad channel, and run with great volume in their season. † Evaporation by an atmosphere which from its extreme rarity and dryness, greedily drinks up moisture, is here amply sufficient to graduate the marginal limit of those lofty reservoirs to the extent of four or five feet, which was the maximum

* The table land of *Thibet* was estimated by European theorists, at eight thousand feet above the sea, though Captain TURNER had shewn the unprecedented rigors of the climate even in so low a latitude, and MOORCROFT'S Narrative had given us a sufficiently frightful idea of midsummer in that country.

† This lake occurs in *Rúpshú* at an elevation of fifteen thousand feet. It is a long sheet of blue water with a varying breadth. My route took me by its margin for a whole day's journey, and I encamped at its eastern extremity where the shore was of turf. No water mark appeared above five feet, and as I was here in the end of September, that may be considered as the limit of fluctuation, a circumstance which was assumed by theorists in regard to *Mánsarovara* as proving the reverse of what Mr. MOORCROFT asserted, or that there must be a drain from the waters of the lake. *Chumoreríl* has likewise no efflux, though several streams pour the liquified snow of the neighbouring mountains into its basin. Evaporation in this dry air is fully sufficient to preserve the balance, and it is more surprising that any water should remain at all, than that no outward communication should exist. The northern margin of the lake is hemmed in by a mass of mountain which shoots up in a nearly mural precipice of bare rock to a height of twenty thousand feet and upwards. The snow rested close to the summit, but in vast bodies, having a cliff of several hundred feet, and but for its dazzling whiteness might have been confounded with the rock itself. It had ceased to melt. In winter the lake freezes, and remains fixed for several months, the snow then accumulates upon the ice and

fluctuation that MOORCROFT observed, and I myself have found to prevail. The hot winds are even there far less parching than the air of the interior *Himálaya* in autumn,—wood, books and shoes warping under it. At *Shipke*, upon the verge of the table land, this dryness was quite withering, and every thing flexible was converted into a coriaceous hardness, and we felt a sensation of intense cold when the thermometer pointed between 40° and 50° , and, under the influence of a strong wind, the effect of a temperature but a few degrees lower was quite benumbing. In the British territory of *Kunáwer*, laying beyond the *Himálaya*, all the fruits are dried upon the tops of the houses at the season of the periodical rains in India. Even turnips are preserved in this way. To this state of the climate is owing the superiority and preservation of all the northern fruits of *Kashmír*, *Kábul*, and *Kundahár*. A circumstance still more surprising in this atmospheric vicissitude upon the immediate verge of an Indian sky, came under my own observation. The fresh roots of the *Rheum palmatum* which I dug up from amongst patches of snow at the solstice in the *Himálaya* ridge, were so brittle in August as to be easily reduced to powder, and moist opium received in *Kunáwer* in the middle of July, was pulverised to an impalpable fineness in the subsequent month,—thus at the most humid period of the year was effected a process that in India is

with the return of spring the gelid expanse breaks up with a noise like thunder, and thaws away, and torrents from the surrounding high land contribute their accessions and rise the surface to its maximum limit. Evaporation now exerts the combined influence of an ardent sunshine and a dry attenuated atmosphere, and by the end of August the lake has sunk to its greatest depression. *Mánsarovara* is precisely similar, but upon a much larger scale in respect to the volume of its waters, its elevation and magnitude of the scenes around it. The water is well tasted, which would seem to argue some outlet, which the oral accounts of the *Lámás* would confirm to be that of the *Satléj*;—as to the egress of any other river in such a situation,—it is a supposition bordering so closely upon a physical impossibility that it need not be entertained. The waters of *Lake Chamoreril* (as might be expected from their having no drain) are unfit to drink, though barely differing in taste from that of running streams. Another lake, two days journey west of *Chamoreril*, at an elevation of fifteen thousand five hundred feet, was found very bitter and brackish, and I was surprised to see wells of the finest water, in the very midst of the salt marshes: innumerable wild fowl covered the entire surface.

scarcely attainable by any length of time, while in Calcutta opium cannot be dried for medical purposes without artificial heat. In Europe the rhubarb roots, at the end of a year, generally require to be baked in an oven before they can be pulverized.

Hygrometrical considerations seem to have been entirely neglected by travellers in India. I was fortunate enough in being put in possession of KATER's hygrometer, in the tour I made to the sources of the *Hyphasis* and *Chunáb*, and across the high land of *Rúpshú* into *Spítí*, which afforded me an opportunity of comparing the state of the air on both sides of the *Himálaya*, and the degree of humidity that belonged to different elevations and situations; the general conclusions from which were, that the atmosphere of the interior regions was more than twice as dry as that which rested upon the southern hills;—that the aspect of vegetation and the rocks corresponded with the indications of the hygrometer, and that the climate of the valley of *Spítí* at an elevation of between twelve and thirteen thousand feet, in October, was infinitely more arid than that of *Subáthú* at four thousand feet, in May and June, when the wind becomes heated and the country parched up. The temperature in the former was between 40° and 45°;—in the latter 80°. The minimum of the hygrometer, in a scale that indicated 1,200, as the point of saturation was .033,† the barometer being then 19.270, thermometer 53°. For a succession of days the range varied between .012* and .055* for the least, and 170 to 190 the greatest, which last always occurred sometime after sunrise‡. At elevations of nearly fifteen thousand feet, the results were not so decisive owing to the presence of clouds in the air and to the great difference of temperature, the correction for which I have

* So written in the MS.; perhaps intended for 33, 42 and 55.

† At *Subáthú*, KATER's hygrometer seldom fell under 100 in a temperature exceeding 90°.—In *Spítí*, in October, the depression was generally 45 in an atmosphere of 50 degrees.

never ascertained.—In these last situations the weather was very cold and unsettled, the thermometer varying from 12° to 41° , with occasional sprinklings of snow. Under analogous conditions the dryness of the air increases with the elevation. I regret having overlooked the wet bulb thermometer which from its principle and simplicity is, without a doubt, the most correct measure of atmospherical humidity: a compensation may however be suggested for the effect of the wind in accelerating absorption.

The face of the country, as far as it has been seen, affords a desolate view to the botanist, but the field is not so unproductive as it looks, and vegetation though scanty, will be found to exhibit many new species and peculiarities. A generic character prevails: most of the plants being armed with spiculæ: furze and spartium form the general clothing of the soil. In animal nature, the scene is equally fertile in variety: and in geology, there is much to interest inquiry; and if elevation is an object of science, the mountain ranges here offer facilities of ascent, which the steepness of the southward *Himálaya*, the snow and the cloudy climate, entirely oppose. It is obvious that angles taken from an altitude of twenty-one thousand feet, would be subject to little or no refraction where the visual ray passes through so thin a medium. From such a position, the highest levels of the country would be accurately indicated, assuming the base to be correct, which barometrical observations would sufficiently establish. Objects visible upon the plane of the horizon, at a distance of one geographical degree, would be actually elevated three thousand feet: the extreme height of the mountain range would thus be readily determined, as the observations would be liable to little discrepancy from atmospheric causes. The climate in summer is sufficiently favorable for a stationary residence, and at twenty thousand feet, one would rarely be exposed to a severer night temperature than 20° , or during the day, to one of ten below 45° , very commonly much higher, from the power of the sun's rays. Observations might be made on the diminished pressure of the air upon

the organs of life and matter, evaporation, and many meteorological phenomena.

The hope of new discovery increases the feeling of gratification we experience in treading over spots unvisited by man. No precious ores have yet come to light, but if analogy is any guide to expectation there is nothing against the supposition, that metallic riches may be concealed in the lofty masses of the interior, which in configuration and structure, correspond to those that produce them in America. This is not a new conjecture, and if they do exist, their site will probably be found in the highest zones of the limestone or clay slate. The lenticular particles of gold which are daily washed from the sand of the *Satlaj* and other rivers, afford no clue to the solution of the problem, but together with the conformation of the mountains and the fact (orally related) of auriferous ores having been discovered in *Thibet*, there is no reason to discard the idea. Copper has already been found at *Síngnam* in *Kínáwer* and in *Spítí*; which is here at least as presumptive of the existence of precious metals as galena is of their mines upon the hither side of the *Himálaya*, which though discovered, seem doomed to oblivion through the timidity and poverty of the chiefs of the soil.

It is to the inner ranges that we must direct research for the germs of metallic wealth, and especially where the great lines of level mark the highest continuity of the country. There is nothing to expect from the primitive formations which shoot up in hard compact masses into the peaks recognised from the plains of *India* as the *Himálaya*.

In the mountains verging on the table land, the rocks are all of the order considered as secondary and of the very class which envelope the treasures in the Andes. In those formations we have in a general view horizontal sandstone, wacke clay, and micaceous slate, and varieties

of limestone, even down to the transition structure that displays itself in caverns, stalactites, &c. &c. and contains animal remains and traces of plants, being often entirely composed of vegetable matter. The soil itself appears in argillaceous earth, beds of gravel, clay, and marle, deposits of gypsum, and a cineritious looking rubble, indicating coal or plumbago. Though no traces of ore are visible upon the surface, those mountains may only differ from the American chain in containing it in the loftiest zone, untrodden by man; but the mineral state of the interior has not yet been examined, and neither the scenes of savage beauty in some places, nor the grandeur of their barrenness in others, have urged adventure to explore scientifically their lofty strata. The fossils of the *Himálaya* in respect to variety, extent, and elevation, are amongst the most curious objects to the naturalist, who sees here the great mass of secondary formations, and even portions of the table land itself, rising higher than the primeval peaks. This is sufficiently remarkable in the lofty level of *Rúpshú* between *Ladák* and *Spítí*, and the still higher belt of country intersected by the *Satléj* between the Chinese frontier at *Shipke* and lake *Mansarovara*, supported by the *Himálaya* on the south, and flanked by the great *Kylas* or *Laochi* chain washed on its northward base by the Indus, beyond which all our knowledge ceases; but information, and conclusions together vague and imprecise as they are, hold out the ground and idea of still loftier ranges, the nature and limits of which we cannot even conjecture. The eternal snows are there repelled to an incredible height, resting partially or entirely vanishing, from the face of the country, very little being here precipitated from skies almost bare of clouds. The rounder and more lumpy configuration of the mountains and gentler undulations of the soil would seem to indicate their structure to be analogous to that of the regions which have come under observation, and the accounts of the *Lamas* confirm the report of calcareous deposits, gravel, clayish, or *kankar*, rubble, and alluvial formations, wherein shells and various organic remains, with petrified bones, are found intermixed with

decomposed felspar and the fossil exuvia of animal matter. From the vast extent of the homogeneous tract, as inferred from the narratives of travellers and the productions of distant points of the plateaux, there is every probability that the whole country lying at the back of the *Himálaya*, the mountain ridges and plains of the interior from the skirt of *Ladák*, and even the limit of *Türkistán* to the table land of the *Brahmaputra* at *Teshú Lúmpú*, abound with fossil relics, the living prototypes of which have disappeared from the earth. The grounds of this belief are not comprised in the productions of the *Spítí* valley; several of the most curious shells having been obtained from remote parts of the interior, but not being objects of appreciation by the people as the *Sulagrâma* stones are in India, they pass unregarded, or are viewed with superstitious reverence as in the case of the fossil bones of the *Mammoth*, considered to have fallen from the clouds. The very few shells which have thus come to light, are chiefly interesting as insulated specimens of the varied resources of the country; being from their unknown sites and position deprived of their value to the geologist, though still identifying the continuity of character, and pointing out an intimate analogy with the fossil geology of opposite regions of the globe.

The valley of *Spítí*, though remarkable for the poverty of its soil and inhabitants, claims consideration in a physical view, the river rolling over a plane, the extremities of which have a difference of level exceeding one mile in a distance of one hundred, a fall unindicated by the appearance of the stream. The declivity is to the south east, and the course so nearly parallel, that with the exception of a single deflection above *Sheedkar*, a straight line would almost lie within the whole channel, a feature in perfect conformity with the homogenous nature of the rocks through which it passes; and wherever an obtrusive formation occurs there the velocity of the stream undergoes a change, all the harder or primitive rocks which enter into the structure of the channel uniformly hastening

the slope, giving the river an impetus, which often roughens to a torrent. In the secondary or softer strata, the channel is less jogged and the surface of the stream smoother, and where the district is limestone, gravelly, or argillaceous, it meanders silently, threading its way in the sand by numerous intersections: a corresponding character is imprinted on the landscape, the mountains betraying their structure in their configuration. The lower region of the dell is very rugged and abrupt, the granite rocks on each side at the conflux with the *Sutlej* cut into mural precipices, hang like vast gates over the slowly emerging river. The eastern wall of this chasm runs up with an unequal slope till it is crowned by the sharp cliffs of *Parkyul*, bordering upon twenty-three thousand feet, and repelling the snow from their arid sides to within three thousand feet of their summits.* With the exception of a few miles at the embouchure, the river upwards, as far as the village of *Chango*, is much inclined, appearing in a line of whiteness. In this neighbourhood, especially at *Shialkar*, the mountains exhibit their sides of rotten argillaceous slate, and at their

* Two of the peaks have been found by measurement, respectively, twenty-two thousand five hundred and twenty-two thousand seven hundred, but it is probable that there are still loftier points in the back ground where it abuts upon the table land. The ridge trends along the *Spiti* as far as *Chango*, where it is deflected to the north east, and softens into vast heaps, being no longer peaked, and the granite evidently running into the secondary class of rocks, and giving the bluff contour to the masses which have a waving gravelly appearance, with a regular slope. Their summits which seem to exceed twenty-one thousand feet are forsaken by the snow. Even after a heavy fall in the beginning of November which covered the face of the country—those arid mountains presented the lightest drapery like hair powder. My lofty position above the cottage of *Changrezing* was upon the slope of one of those enormous heaps, and they extended towards the chain of red peaks with an ascending elevation.

In a notice by Mr. COLEBROOKE in some English publication, upon the comparative results of various measurements in the *Himálaya* regions, made by Captains HERBERT and GERARD, he remarks that the only great difference between the observations of the two Surveyors occurred in the altitude of *Parkyul*, where this amounted to three thousand feet, which is a mistake either on the part of Mr. C. or in the statement of the case. The station upon the slope of *Parkyul*, at nineteen thousand five hundred feet, being confounded with the crest of the peak which is twenty-two thousand five hundred feet, a discrepancy of sufficient magnitude to lessen the dependence to be placed upon the accuracy of all the results.

bases we see tumuli of loam like potter's clay protruding through the black soil. The eternal snow (summer line) here recedes to nearly twenty thousand five hundred feet, on a south western exposure, the bottom of the valley being itself ten thousand feet above the sea, but the effect of solar radiation in this arid concave modifies a climate, which, in insulated elevation would be unproductive of grain, to a temperature capable of rearing consecutive crops in the proper season.

Upwards from *Sheealkar*, the river has a slower acclivity. The marginal rocks crumbling at their surface terminate in smooth slopes of finely comminuted matter, and finally in steep dead sand, which repels both vegetation and snow, till near *Dánkar*, where the valley making a sharp flexure, resumes its natural direction, deriving a new feature from the transition of the rocks which now mark the fossil district, and open out at their base to a flat pebbly expanse of three furlongs.

The scene now begins to wear a desolate grandeur; every object is arid, the parched and thirsty soil ceases to shew a glimpse of verdure. The river winds its course in streamlets through a bed of sand and pebbles. The section of the rock being very steep exposes the stratification, which is here slightly inclined from the horizon. *Dánkar* itself is perched upon a projecting ledge of conglomerate limestone, rising out of the valley in steep indurated masses, which the erosion of time has filed into slender spires and the percolation of snow eaten away at their bases till they present a groupe of turrets and ravines almost deceiving the senses by the effect of natural agents. These lofty piles have a compact solidity which resists the hammer. Their sides are often scooped into places of abode, and the natural excavations are taken possession of by monks and a vagrant priesthood, who detaching themselves from the rest of the world like the Druids of old, are to be seen peeping out from their isolated niches.

The valley beyond this point preserves a considerable expanse, varying with the structure of the mountains, which sometimes jut out in hard black masses, contracting the river, but the bed continues pebbly and unhampered by rocks. The near cliffs on each side rise to about sixteen thousand feet, and are entirely bare, the snow resting at twenty thousand feet upon southern aspects, and except in hollows, not greatly lower on shaded sides.

At the village of *Rangrit*, two days journey about *Dánkar*, the basin of the river has a fine spread, and is here intersected by sandy islets, bearing Tamarisk bushes and a turfy vegetation, whereon the flocks feed in winter by scraping through the snow. The country has the same arid complexion, and encroaching barrenness alone marks the course of the valley, while gleams of the snowy frontier of *Rúpshú* are seen through the defiles of torrents, and a sharper section of the mountains foretells approach to its recesses. The cultivable step is greatest upon the right bank, the cliff of which, on both sides, from one to two hundred feet high, is worn into pillars like gigantic minarets. Their composition is an aggregate of gravel, pebbles, or calcareous rubble; the left alluvial sediment of the river baked to a rugged hardness by the sun's rays, and tapering into cones which are frequently crowned by a flat stone like an entablature; their bases eaten away till they fall within the perpendicular, and altogether so frail as to appear to the spectator who passes them, an impending danger which hastens on his steps; yet they stand erect, crumbling only at their surface, and, subsiding imperceptibly to the surrounding level, vanish amidst their own ruins, from which others again take their rise, and in their slow formation and slower decay, they record long periods of time, being the last remains of a bank or entire section that has thus worn away. These groupes of tumuli which are often left insulated upon the steepest slopes of the mountains, where all around is uniformly smooth and bare of vegetation, are viewed with timid curiosity by the traveller,

who descries them from afar through the loaming air like fortified castles, but here man is not his enemy.

At this point of the valley the river has an actual elevation of twelve thousand feet, and the narrow inhabited slip, from two to four hundred feet higher, trends on each side with a steep cliff to the stream, backed up by the bases of the mountains which here assume a perpendicular form, and the gradual erosion of their surface has thrown up heaps of finely attrited matter that reaches high upon the sides of the rock no longer visible, and in the course of time will overtop the loftiest peaks, and the whole country be thus buried in its own dust by a process of nature, which, however slow, is inevitable and irresistible.

The rise of the level continues beyond *Rangrík*, at the rate of thirty feet a mile; the river winding with a varying expanse and making sharper flexures; the rocks of a packed structure assume a bolder and more lumpy form, their inward faces steep and scabrous, terminate in flat summits, or are deflected in a slanting plane at a medium height between sixteen and seventeen thousand feet, a limit which is occasionally whitened by snow at mid summer. These are but the cheeks of the river, and the roots of a parent chain on each side which towers majestically in the back ground. The villages of *Hayl* and *Hansi* rest at an elevation between twelve and thirteen thousand feet: here the river is still of considerable volume, but fordable with some exertion; and at *Lossur*, the last inhabited spot, a few miles higher, the stream was found so much reduced that I crossed it with ease upon a man's back in the month of August, but the width of its bed argued its much greater size at an antecedent period of the year. Beyond *Lossur* the river has not been traced. On coming down upon the village from the heads of the *Chun'ib*, I found its bed, at a spot nearly a mile higher, to have an elevation approaching to thirteen thousand five hundred feet, and the slow rise

of the river onwards, as shewn by the flatness of the channel and creeping progress of the stream, indicated the forks to be still at some distance, and the valley, before it breaks into a gorge, to have a vast altitude, perhaps not under seventeen thousand feet. The nature of the country at *Lossur* partakes of the general arid display. The mountains are more continuous, and throw out their cliffs like a wall, where neither snow nor soil can rest; their tabular summits adding a new feature to a scene of calm desolate grandeur.

In August the crops were still green and the morning temperature at 42°. The village occupies a slip of soil at the feet of the mountains, and cultivation descends in a slope graduated for irrigation. The people are even darker here than in the lower and warmer regions, and when the ground is covered with snow the black figures moving into sight have a very grotesque appearance, as they glide along the sheeted surface to which they form so sad a contrast. Mankind here, like plants in other climes, groupe together for mutual comfort and protection against the pressure of the climate. Lofty as the level of *Lossur* is, there is little in the landscape to betray its position when viewed in summer embosomed in flourishing crops and herds of shawl-wool goats. Yaks and horses meet the eye upon the high acclivities of the mountains, and an ardent sunshine keeps the air loaming from the effect of mirage. The *Spítí* below in its smooth sandy bason might even be recognised as a stream in the plains of *India*.

I had no opportunity of obtaining precise information about the remainder of the river, much less of following it up; but from the conformation of the channel and glance along the stream, while I stood in its bed, I have no doubt that it penetrates several days journey beyond *Lossur*, and that it forms the base of direction to a pass into *Rúpshú*, which by inferences from another, at a lower point of the valley, may be

concluded to be upon the verge of nineteen thousand feet, and as the streams from that elevated level still flow by a circuitous course into *Spítí*, (none finding a slope to the *Indus*) there is the most presumptive proof for the supposition of higher ranges in the area included between that river and the *Satléj* than has yet been observed in the detached cliffs of the *Himálaya*, which seen from spots little elevated above the sea, in sharp towering peaks, impress by their imposing portraiture an idea of greater altitude than that which is recognised in the mountains behind them, where this effect is absorbed in the vast elevation of the soil from which they rise, and the very lofty position of the spectator who views them. The mountains upon the Tartaric frontier derive from the elements of their formation a rounder contour, appearing like gigantic sand heaps. We here behold them as it were planted upon a plain, which is itself more than half their entire height. The stream of the *Satléj* at *Shipke* has already risen to nearly ten thousand feet, and at *Bekhar*, thirty miles farther, it approaches to eleven thousand. At the town of *Daba*, under *Niti* pass, and eight days journey from *Mansarovara* it verges upon fifteen thousand; limits which, if in insulated elevation, would of themselves be considered as very lofty, are here lost in the continuity of the neighbouring surface, and the highest ridges are apparently diminutive, and where the lines of level reach a greater altitude the inequalities of the soil become quite insignificant. In the plains and vallies of *Rápshú* I found myself surrounded by black conical hills of from three to four thousand feet, mere heaps, yet they had a positive height of twenty thousand, the flat expanse at their base being here sixteen thousand. Lake *Chamoreríl*, the greatest depression of the soil was still fifteen thousand feet above the sea, while Lake *Mansarovara*, from conclusions grounded upon barometrical observations made in the course of the *Satléj*, appears to be at least seventeen thousand. It is not surprising then that the country of the *Oondes*, or *Hun-dès*, seemed to MOORCROFT to be less lofty than the *Himálaya*, and that even *Kylás*, so conspicuous an object of reverence and superstition, elicited no mark of admiration when

seen from a position so elevated, that *Chimborazo* itself would look like a mole hill, and the highest summits of the *Himálaya* cease to appear majestic. Subsequent travellers have been equally deceived by the aspect of the interior, and though aware of their own elevation, erred prodigiously in their conclusions on the height of the country. Seeing the mountains under a less abrupt form, and only capped with snow produced a conviction of their depressed altitude, and that the whole surface had a downward tendency; a knowledge of the reverse may be now safely hazarded even upon the rude approximations which have been obtained. A traveller in *Rápsá* finds himself, for days together, upon a level between fifteen and seventeen thousand feet, which runs in flat slips, or slightly inclined valleys, formed by the intersections of the mountains which are crossed at their depression, between eighteen and nineteen thousand feet; but this broken land already borders upon *Ladák* and the *Indus*, the bed of which under *Leh*, the capital, has probably an elevation exceeding eleven thousand feet, yet the country all around was very high, and the distant mountains in sight not only uniformly white in a region where the perennial snows rest beyond twenty thousand feet, but this belt was very broad, and the aspect was more that of mountains of snow than snowy mountains, my own elevation being here eighteen thousand feet; circumstances of themselves arguing vast height and removing at least much of the uncertainty and many of the errors which the consideration of such a subject would involve under the usual elements of the problem.*

* Barometrical results from their extreme simplicity and facility of observation, have not received due estimation in Geometrical operations, while inaccuracy in the instruments or observers have justly depreciated their value. It will however be found that with the correctness of which they are susceptible, their indications will approximate so closely to Trigonometrical measurements as to leave the question of superiority doubtful. I allude here to those Mathematical operations, which, by their conditions, exclude every source of error arising from refraction or the determination of the base and angles of the triangle: in cases of considerable difference in which the triangulation involves long distances, and in instances where two of the angles can only be observed, barometrical conclusions deserve the preference, and in almost all are indispensable adjuncts, and afford satisfactory verifications, while the most interesting portion of Physical Geography, the lines of level which

The idea of other and still loftier ranges beyond those gelid scenes, extending along the southern skirt of the *Indus*, is strengthened by the information of the goatherds upon the spot; but those observed from a barometric level of 15.520, answering to eighteen thousand feet, where the

regulate climate and vegetation, the sections of river courses and the planes of water communication throughout a country admit of no other method. On comparing the circumstances which affect the conditions of the respective operations, we shall see that the refractive power of the atmosphere involves a source of error of infinitely greater extent and uncertainty than the variations in its gravity which almost alone enter into Barometrical computations, and can be compensated by the medium of a large range of simultaneous observations. In cases of small angles at great distances the uncertainty of refraction must always prevail, and in the various degrees of temperature and humidity of the medium through which a ray of light passes from an object in the *Himálaya* to the eye of an observer upon the plain of India, if the angle is less than 1° , the undeterminable quantity might be sufficient to vitiate the whole calculation, if this is made with reference to a fixed point, but without assuming the extreme limits of error which are liable to result from the deflection of the visual ray in an atmosphere, varying in temperature within the points of observations to 70 or 80 degrees, the uncertainty still remains as to the quantity to be allowed for the intercepted arc, in cases where the three angles of the triangle cannot be observed, which include all the grand points of the chain, and for which allowance there is no precise measure, and a mean from the extremes only reduces the height of an object within the limits of a very considerable space, in many cases exceeding a thousand feet. With respect to Barometrical heights, much superfluous objection has been made in regard to the variations in the specific gravity of the mercury arising from natural impurities or adulteration, but which are notwithstanding, limited to a mere imaginary compass, from the impossibility of alloying the metal to any appreciable extent, without rendering it useless for the purpose. These are however, determinable errors, which may be destroyed entirely. In the dry and brilliant regions which have disclosed the scenes of gigantic grandeur alluded to, refraction becomes a computable element; from stations elevated eighteen and nineteen thousand feet, the angles of the most distant objects would be subject to little derangement from variation in the density of the atmosphere and vertical bases which are generally within our reach, by their proximity to each other, would prevent the accumulation of error by reducing the interval between the observation of the angles to an almost cotemporary result; another advantage occurs in Barometrical levels at very lofty stations in the slight changes of atmospheric density, or at least the uniformity of the fluctuations. It is true that it requires but half the extent of the oscillations in the mercurial column here, to produce the same effect (error) as at the level of the sea, but this is equally appreciable at the highest as at the lowest regions, and the discrepancy (whatever this may be in an altitude of four or five thousand feet, is not liable to be augmented in that of eighteen or twenty thousand, a correction for the hygrometric state of the air seems still a desideratum in Barometrical calculations. Under all the circumstances of the measurement when made with accuracy and the necessary compensations, we may safely

night temperature was 13° on the 23rd September, had a sufficient angle to approximate their altitude to twenty-five thousand feet, and this not in a few detached points but a continuous line of peaks, while the paler snows which encircled the summits of the most distant, indicated them to be still loftier, and without assigning them the extreme height, (in that of

assign two hundred feet for the maximum limit of error in the greatest altitudes, and at the most remote distances from the site of cotemporary observations, a quantity not so great as results between separate Geometric operations by the same person or between different observers, and even less than the difference in the computations of separate individuals from the same premises, and infinitely less than the limits within which refraction varies in the ordinary state of the air. An application of the argument is found in the *Chúr*, an insulated mountain ridge, twelve thousand one hundred and forty-seven feet high, in the hill state of *Tirmúr*, north of *Náhu* and *Saháránpur*, chosen as the grand Trigonometrical station for the survey of the country between the rivers *Satlej* and *Jamna*, and its altitude fixed by a series of simultaneous observations made under different circumstances of seasons and temperature upon its summit, and *Saháránpur* upon the plain at an oblique distance of about fifty miles. This being an accessible spot, all the angles of the triangulation were observed and the amount of refraction determined, the greatest accuracy is therefore due to the operations. Several years after, I visited the spot on the day of the summer solstice, at the commencement of the rainy season, when the difference of temperature between the peak and the plains was about fifty Thermometrical degrees and the atmosphere variable. The Barometers I used were constructed by myself upon the spot. The tubes, though under twenty-eight inches, exhibited a perfect vacuum, the mercury having been boiled within them. The scale was a fir rod, the horary observations were made at my camp seventy feet below the summit, and several were taken upon the extreme point of the peak, the result of the whole as calculated from simultaneous observations at *Subathú* the height of which was fixed, came within three feet of that deduced by the most accurate operations of trigonometry which is perhaps proving too much. A subsequent measurement, at an interval of some years, and computed from Barometrical observations at Calcutta, was within a few feet of the same result. The uniformity in Barometrical indications proves their accuracy. Far loftier spots than the *Chúr* have been visited at different seasons of the year, and with different Barometers with the most satisfactory results. The passes in the *Himálaya* at fifteen and sixteen thousand feet, in the midst of eternal snow. Those upon the verge of the table land at elevations of eighteen thousand feet, in a bleak arid country, and stations upon *Parkyúl* at nineteen thousand five hundred feet, and the difference in the respective heights seldom approached to one hundred feet, though the temperature under which the observations were made sometimes varied forty degrees. Upon every consideration then, the Barometrical levels taken in my journey to the skirts of *Ladák*, and at various times upon the frontier of the Chinese territories, may be depended upon as true indications, though I have not attempted to reduce them to measurement, but contented myself with general conclusions, in round numbers, as more consistent with the nature of the subject.

a solitary peak,) there is ample room to confirm their rivalry over the southward *Himáluya*.*

The snowy chain, west of the *Ganges*, is crossed at elevations of between fifteen and seventeen thousand feet, and rarely the latter. At the sources of the *Hyphasis* in *Kúlú*, the depression of the *Himálaya*, at the pass of *Rotang*, is as low as thirteen thousand feet, but the northern ramifications of the chain are traversed in an ascending series in that of the *Paralassa* and *Láitche*, long ridges, respectively sixteen thousand five hundred and seventeen thousand feet; a third which formed my nearest appulse to *Ladák*, was approached by a valley itself elevated sixteen thousand feet, and from the steepness of the slope in its winding course beyond my position, I concluded the pass in the range to border upon eighteen thousand feet. The contiguous peaks, at a far higher level, were perfectly black in the middle of September,—but before reaching *Ladák*, another range, the *Parang Lá*, is crossed, which being sheeted in snow, and the passage expressly described as attended with laborious respiration, debility, and the usual effects of a highly rarified atmosphere, we may infer to be still more lofty.† This chain runs upon the limit of the *Indus*, and is no doubt continuous with the line of cliffs already noticed, which appears to stretch away uninterruptedly to the forks of the river near *Mansarovara*. Pursuing the analogy, by going eastward, the passes to

* This measurement excludes the still loftier limits which have been assigned to *Dhawulgiri*, *Chamalári*, and other peaks in the south-eastern quarter of the chain which have not afforded the same advantages of verification, and may still be considered as desiderata. A few others have indeed been determined at twenty-three and twenty-four thousand feet, but even those detached points can scarcely be taken as a measure of the magnitude of the range as compared with the vaster continuity of the interior ridges of the table land.

† There is some uncertainty whether this range of mountains is crossed by the route I followed, but it exists and is represented as a very formidable barrier. My nearest appulse to *Leh*, the capital, appears to have been still five days' journey distant, which allows ample space for the intervention of the snowy ridge of *Parang Lá*.

Stango, *Bekhar*, and between different points of the *Satlej*, on the table-land, are all beyond eight thousand feet, and one from *Sungnam* in *Kandwer*, into *Spítí*, cuts the mountains at an elevation of eighteen thousand seven hundred feet, while the communication with *Rupshú*, from the valley, is still higher, shewing the barometer at 15.120 on the 30th of September at noon. This magnificent boundary is of secondary formation—if by this is understood rocks of stratified limestone, intermixed and alternating with argillaceous slate, masses of hard sandstone and a coally looking substance. None of the primitive rocks are met with in the upper course of the *Spítí*, but near *Shíalkar* they are conterminous with transition formations, where the stream of *Parátí*, from the broken land on the north, defines their limits in that direction.

The geological structure of the *Spítí* district commands a high degree of interest from its numerous fossil remains, and the singular elevation and magnitude of the scenes which represent them, the mountains in many places appearing to be formed entirely of shells, and their exuvæ. Specimens of these fossils have been sent by me to Calcutta, where no doubt they will have been duly appreciated and elucidated by those who are more conversant than myself with the subject of fossil conchology. Some of the fragments were broken from masses of rock lying at the foot of a cliff from which they appeared to be detached, at a height of 15,000 feet. The cliff rose like a wall abruptly from the river, but its eastern side sloped off from a crest of 16,500 feet high, where some ammonites were found. Illness, and the languor produced by such an attenuated atmosphere, prevented my taking every advantage of my visit to this interesting region, and my journey was terminated by the limits of the British territory. Just before crossing the boundary of *Ladák* into *Basáhr*, I was gratified by the discovery of a bed of marine fossil shells resembling oysters, and clinging to the rock in a similar manner, but the suspicions of the Chinese prevented my bringing away many specimens. The loftiest position at which I

actually picked up some of the shells was on the crest of a pass elevated 17,000 feet, where also were seen numerous blocks of the calcareo-silicious matrix. I was not able to pass more than a single day at this interesting spot, but I brought away numerous fragments of the rock. If the observation of shells and mountain strata of organic remains at such an altitude be worthy of attention to the geologist, I am happy in having enjoyed the opportunity of verifying the fact—leaving to more experienced hands the recognition of the species and the age of the fossils, the classification of the strata in which they are imbedded, and the theory of their being raised to their present elevation.

NOTE.

It will be seen by the heading of this paper, that it contains only the "first part" of Dr. GERARD's observations on *Spíti*, and treats of the geography, elevation, and climate of the valley; the second part, which was to have described more particularly the geological features of the country, in illustration of the fossils presented by the author to the Society, has been delayed by Dr. GERARD's journey to the *Orus*, and cannot now arrive in time for insertion in the present volume: the last paragraph has therefore been added from information contained in the author's letters to the Society accompanying the specimens. It may also be convenient to notice here that duplicates of many of the shells described in the Rev. R. EVEREST's memorandum, page 107, were sent at that gentleman's request to Mr. SOWERBY, author of the "Mineral Conchology," the substance of whose reply is here subjoined, with alteration of the numbers, that they may coincide with the figures of the plates of Mr. Everest's paper.

Extract from Mr. J. D. C. Sowerby's letter to Mr. James Prinsep, Sec. Ph. Cl.

"I had before seen some specimens from the same mountains in the possession of Mr. STOKES and Dr. BUCKLAND, among which were several ammonites that are as yet unnamed. The Rev. Mr. EVEREST's deductions are correct as far as they relate to the formations the fossils belong to, as will be seen by the accompanying list of names, to each of which I have added the formation in which that species occurs in England. In the genus *Terebratula* there are many species that cannot be depended upon as indicating particular formations, because very similar ones are found in several beds, and the species are difficult to determine, especially if not quite perfect. The *Pecten*

mentioned as resembling the common scallop (of which no specimen was sent home) is probably the *P. equivalvis*, which is characteristic of the inferior oolite; the *Helix* mentioned also may possibly be *Ampullaria nobilis* which accompanies the *Cirrus* in the lower beds of the mountain limestone of England and Ireland."

5, Camden Terrace, 14th October.

List of Himálayan Fossil Shells.

Pl. I, Figs. 2, 3, 5—*Ammonites annulatus, anguinus* of Schlotheim, *Zeiten Versteinerungen Würtembergs*;—t. ix. f. 2. Min. Con. tab. cccxii. fig. 5 is the same shell:—Lias formation. The large specimen is filled with sulphate of barytes.

16—*Belemnites sulcatus*, Sillot, Miller, (*Trans. Geol. Soc.*, 2d series, vol. II, pt. I, pl. 8, fig. 3, 4, and 5.) *Bel. apiciconus*, Blainville's Memoire. Lias, inferior oolite.

15—*Alveolus* of a Belemnite, perhaps of *B. sulcatus*.—*Orthocera conica* of Min. Con. tab. ix, although called an orthocera, is only an *alveolus* similar to this.

Pl. II, Fig. 19—*Aricula* (rather than *pecten*) new species.

22, 23—*Spirifer striatus*. (Min. Con. tab. cclxx.) Mountain limestone.

25—Cast of the interior of the same shell.

24—*Producta scabricula*. (Min. Con. t. lxix. fig. 1.) This and the *Spirifer* are in a stone strongly resembling some of the Transition slate of England.

26—*Astarte planata*, var. (Min. Con. tab. cclvii.) Inferior oolite. A variety of this shell is found at Bayeux in Normandy, and is called *Crassina modiolaris*.

28—*Nucula*, an unnamed species; similar fossils occur in the mountain lime and lias.

29—strongly resembles a portion of some large *Inoceramus*, but is not perfect enough to determine."

Of the other shells depicted in the plates, there were at that time no duplicates for transmission to England. The shells in Plate III, are for the same reason unnamed.

J. P.

XVI.

N O T E

ON THE

DISCOVERY OF PLATINA IN AVA.

BY JAMES PRINSEP, F.R.S., *Sec. Ph. Cl.*

THE first suspicion of the existence of Platina in the Gold Dust of *Ava*, occurred to Mr. CHARLES LANE, a merchant residing at the Burmese capital, *Amerapura*, in 1830. That gentleman transmitted through Major BURNEY, the Resident, a small button of the suspected metal, along with other minerals, to Mr. GEORGE SWINTON, who presented them to the Asiatic Society on the 15th January, 1831.

A Note on the examination of this button was published by myself in the GLEANINGS IN SCIENCE for the following month, in which it was shewn that the metallic bead was a fused alloy of platina, gold and iridium, with iron, arsenic and lead. It had a specific gravity of 17.2, and was fusible at a forge heat into a round button. At a temperature of 1900° under a muffle, it assumed a dull granular spongy texture and a dark black colour, without loss of weight. The lead had no doubt been added to render the metal fusible: and when once united, there is known to be great

difficulty in again separating the metals. Platina cannot be purified by cupellation like gold, on account of its infusibility, which causes the alloy to solidify before the whole of the lead has been oxidized and driven off.

Having expressed a desire to obtain some of the native mineral in grains, Mr. LANE was so kind as to send a specimen which he had with difficulty procured in the course of the following year : but he was never able to send a second supply ; so, being unwilling to consume the whole specimen in an analysis, I have contented myself with a rough examination of a small portion.

Before giving the results, however, it may be useful to bring together into one view the whole of the observations of the discoverer, and of Major BURNEY, on the locality and mode of extraction of this precious mineral.

Mr. LANE's first announcement was expressed in the following terms :

“ ‘Mixed with the gold dust, found to the northward of Ava, are a quantity of grains of metal, having every appearance of iron ; they are easily corroded, and are also affected by the magnet : by melting these grains, and keeping them in fusion, until the metal is no longer observed to scorify, the enclosed button of metal is left at the bottom of the crucible.

This metal, when mixed with gold, is found to increase its brilliancy. The King's ear-rings are made of a small quantity of it, mixed with pure gold ; it is very brittle, and all our attempts have hitherto failed in making it malleable.’ ”

In addition to this information, Mr. SWINTON received the following particulars from Major BURNEY in January 1832.

“I find that a good deal of the platina ore is brought from some mountain torrents, or small streams, which fall into the *Kyendween* river from the westward, near a town called *Kannee*; and it is collected in a very curious manner, as Mr. LANE is informed, although he hesitates to believe the fact. The horns of a species of wild cow in this country called *T'sain*, perhaps the same as the *Nylgao* of India, have a velvet coat before the animal reaches the age of two or three years: a number of these horns are taken and fixed in the beds of the small streams, and at the close of the rainy season, when the water subsides, a cloth is put down over each horn separately; and the horns, and cloth, as well as a portion of the sand around them, are taken up together. The horns appear to collect around them a good deal of gold dust, which the streams have washed down, and with this dust grains of platina are found mixed.

The Burmese look chiefly for the gold dust, separating and bringing that alone generally to Ava; and although Mr. LANE has often urged the men who are engaged in this trade to bring at once the whole of what they take up with the horns, he has not yet been able to persuade them to do so. These horns sell sometimes for 12 or 13 *ticals* a piece: deer's horns are sometimes used instead of them.

The Burmese call platina, *Sheen-thán*; much of this ore is also found with the gold dust collected among the small streams which fall into the *Irawádi*, to the northward, in the direction of *Banman*.”

ANALYSIS.

One hundred grains were taken for the determination of the specific gravity. They were immersed in water in a small glass tube, for which a counterpoise had been previously adjusted, and the air was taken out by exhaustion under the receiver of a pneumatic pump. 0.2 grains remained floating on the surface of the water, which, on examination with a

microscope, proved to consist of spinel, augite, silex, and one very minute emerald

The specific gravity of the mixed grains at 75.° was 12.17.

Fifty grains, dried, were then taken for analysis.

1. From this were separated, under the microscope, 0.5 grains of gold.
2. The magnet removed also 0.4 of small black grains, supposed to be crystalized magnetic oxide of iron.
3. The remainder consisted of two portions, which were imperfectly separated; A, shining scaly grains of a silver colour; & B, dark black grains.
4. The white metallic scales (A) had a specific gravity of 9.10—the quantity separated weighed 8.5 grains. The black residue (B) weighed 40.6.
5. The silvery scales (A) were digested in boiling nitric acid, and caused a slight disengagement of nitrous fumes. The solution was not affected by muriatic acid, and consequently contained no silver; but carbonate of potash threw down a slight flocculent white precipitate, weighing less than 0.2 grains, which was not examined. It was probably carbonate of iron. The scales were then digested twice in boiling nitromuriatic acid, which acquired a deep orange colour, but left undissolved a portion of the scales and such of the black grains as had not been thoroughly separated from the rest: the weight of this residue was 3.7 grains.
6. The separated portion of dark grains (B) was also boiled several times in concentrated nitromuriatic acid, which took up 16.4 grains, and left untouched 24.2 grains, among which were discernible several of the shining scales not separated in the first instance.

7. The two nitromuriatic solutions were mixed together and treated with muriate of ammonia, which threw down a copious orange precipitate of the triple salt of platina, weighing 21.9 grains, which are equivalent to 9.45 of metallic platina, or nearly twenty per cent.

8. The solutions still retaining their orange red colour were treated with carbonate of potash, which precipitated at first mere oxide of iron and afterwards a bulky gelatinous precipitate of a light yellow colour, which was left unexamined for want of leisure, but which was supposed to contain a small portion of some earth mixed with carbonate of iron.

9. The undissolved residue of A and B, 27.9 grains, was mixed with caustic potash, and heated to redness in a platina crucible, according to the formula of WOLLASTON, to rid it of silicious matter which prevents the ready solution of the metallic grains. The fused mass was dissolved out of the crucible with weak muriatic acid, and was boiled in the same, imparting to it a bright yellow colour. The black grains remained in deposit, and were but little affected even by repeated boiling in nitromuriatic acid. The process was repeated with the same want of success. 21.82 grains of a fine heavy blue-black powder remained out of the original 28 grains: much of the difference must be attributed to the loss in such an operation upon a fine powder;—a part, however, is accounted for in the earths and iron taken up by the muriatic acid.

10. According to the experiments of R. BINGLEY, Esq., H. M. Assay-Master, at the London Mint, small portions of platina and its companion metals in alloy with gold may be separated by the ordinary process for refining gold, or quartation with silver and solution in nitric acid. I therefore endeavoured to obtain a solution of the refractory metal by uniting it with gold.

For this purpose, 2 grains of the black powder were wrapped up in a plate of pure gold weighing 20 grains, which was again enclosed in 50 grains of pure silver, and the whole fused together in a wind furnace. The bead exhibited black specks, as of iron oxide, on parts of its surface, but most of the powder had united with the compound metal.

On lamination and dissolution in the usual way, the nitric acid did not acquire any peculiar colour, and the gold cornet, when annealed, shewed the same spotted appearance as had been remarked in the button : it had a weight of 21 grains. On solution of this gold in nitromuriatic acid, the liquid took a dirty green colour from the suspension of a very fine dark blue powder, which quickly subsided, and had the same appearance as at first. The powder was placed in a Stourbridge clay crucible and urged in the heat of a forge until the crucible melted, without reduction of the powder to the metallic state ; and it was only upon subjection to the oxihydrogen flame that it was agglutinated into a bright metallic sponge, similar to that of the iridium separated in the analysis of the platina button from *Ava*, before alluded to.

From the above imperfect examination, it appears that there is a predominance of iridium in the *Ava* platina ore to a much larger extent than in the ores from *South America* or from the *Ural* mountains. I hope hereafter to obtain a more copious supply of the mineral, and then to ascertain the presence of oxmium and the other metals which usually accompany platina. The present Note has been drawn up solely with a view to certify the interesting fact of the existence of platina among the gold washings of the *Ava* rivers ; and in connection with that fact it may be farther stated, that the platina constitutes 20 per cent. of the cleaned ore, and that it is accompanied with about twice its weight of iridium. The remainder appears to be chiefly oxide iron.

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A P P E N D I X.

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ADAM, J. ESQ. (late).—A specimen of the *Ornithoryncus Paradoxus* from Van Diemen's Land.

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- WARD, MR.—Specimens of the Calcareous Deposit found about the hot spring in Bencoolen.
- WATSON, COLONEL T. C.—A Model of Theodore Jones & Co.'s Suspension Wheels.

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